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THE EVALUATION OF SEEDBEDS, METHOD OF SEEDING, AND SPECIES FOR RESEEDING ARID RANGELANDS OF ARIZONA

Pima, Congress, and Fredonia Areas

A Progress Report for the Calendar Year

1965

submitted to

The Bureau of Land Management
United States Department of the Interior

prepared by

The Department of Watershed Management
Agricultural Experiment Station
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INTRODUCTION

This is a progress report for the calendar year 1965 covering the experimental range-seeding studies conducted near Fredonia, Congress, and Pima, Arizona. At each location several methods of seedbed preparation and shrub control were compared for their effectiveness in establishing various range grasses. On each seedbed the relative effectiveness of different times and methods of seeding was also evaluated. Although the vegetation, climate, and soils varied among the locations, the objectives common to all locations under study are as follows:

(1) To evaluate seedbed preparations and methos of seeding to more effectively revegetate the range type under study.

(2) To evaluate both chemical and mechanical methods of shrub control.

(3) To select those forage species best adapted to the particular range type.

(4) To determine, by appropriate instrumentation, the micro-environmental conditions limiting the germination, growth, and establishment of grass seedlings.

The previous progress report of 1964 has covered in general the geography, legal description, native vegetation, climate, and soils characteristic of each location. These general characteristics will not be enumerated again. Where additional data have been obtained, they will be included in this report. The tabulation of the climatic factors (precipitation, temperature, and relative humidity) was continued

for each area in 1965. The importance of the various climatic and edaphic data will be discussed in relation to the results from the different seedings. For the Fredonia area, the climatic data were supplemented by readings from an anemometer and an evaporation pan. For the Congress and Pima areas, new data are presented from soil analyses of these areas.

Each of the areas are under fence to protect them from grazing by livestock. The seedings are further protected from rodents and rabbits by the use of poisoned salt licks. The degree of successful control of rabbits by using poisoned salt licks has varied from high to low. In addition to the use of poisoned salt at Fredonia, the species adaptation studies were protected by a rabbit-proof fence.

At each of the areas, species adaptation studies were continued as started in 1964. In these studies, about 20 of those forage species considered to be possibly adapted to the particular area are seeded in a small nursery. Data from these nurseries, consisting of plant counts made in the fall, are presented for both the 1964 and 1965 nurseries.

The main data in this report relate to the evaluation of seedbeds and time and method of seeding. These data consist of the average number of plants per 100 square feet on each seedbed and seeding variable studied. Plant counts have been made on both the 1964 and 1965 seeding studies at each of the areas during the fall of 1965. The results from the counts from both years are presented in this report to evaluate the progress of last year's seeding and to evaluate this year's seeding in relation to climatic and edaphic conditions.

Photographic data will be included where applicable. Additional data are included for the Fredonia area which relate to the degree of competition from globe mallow and sagebrush on the various seedbeds.

THE CONGRESS AREA

The Congress area is located in west-central Arizona. The exact location of the study site is shown in Figure 1. This is a region of comparatively low rainfall of about 9.5 inches annually. This aridity is reflected by the sparse cover of shrubs consisting mainly of creosotebush, mesquite, and snakeweed. The percentage crown cover and density of plants per acre for the native vegetation is shown in Table 1. The total coverage for the 1965 study site was 4.14 per cent. The only perennial grass found in the area was tobosa.

Table 1. The percentage crown cover and density of plants per acre of the native vegetation occurring in 1965 on the range reseeding site at Congress, Arizona.

Species	Percentage Cover	Number of plants per acre
Creosotebush (Larrea divaricata)	1.02	29.5
Mesquite (Prosopis juliflora)	1.07	12.0
Tobosa (Hilaria mutica)	0.60	607.0
Snakeweed (Gutierrezia sarothrae)	0.45	357.0
Catclaw (Acacia greggii)	0.33	3.5
Grey-thorn (Condalia lycoides)	0.24	5.0
Cane cholla (Opuntia thornberi)	0.13	37.5
Cactus (Opuntia sp)	0.23	9.0
Joshua-tree (Yucca brevifolia)	0.07	0.5
Baccharis (Baccharis sarothroides)	____	1.0
Total	4.14%	

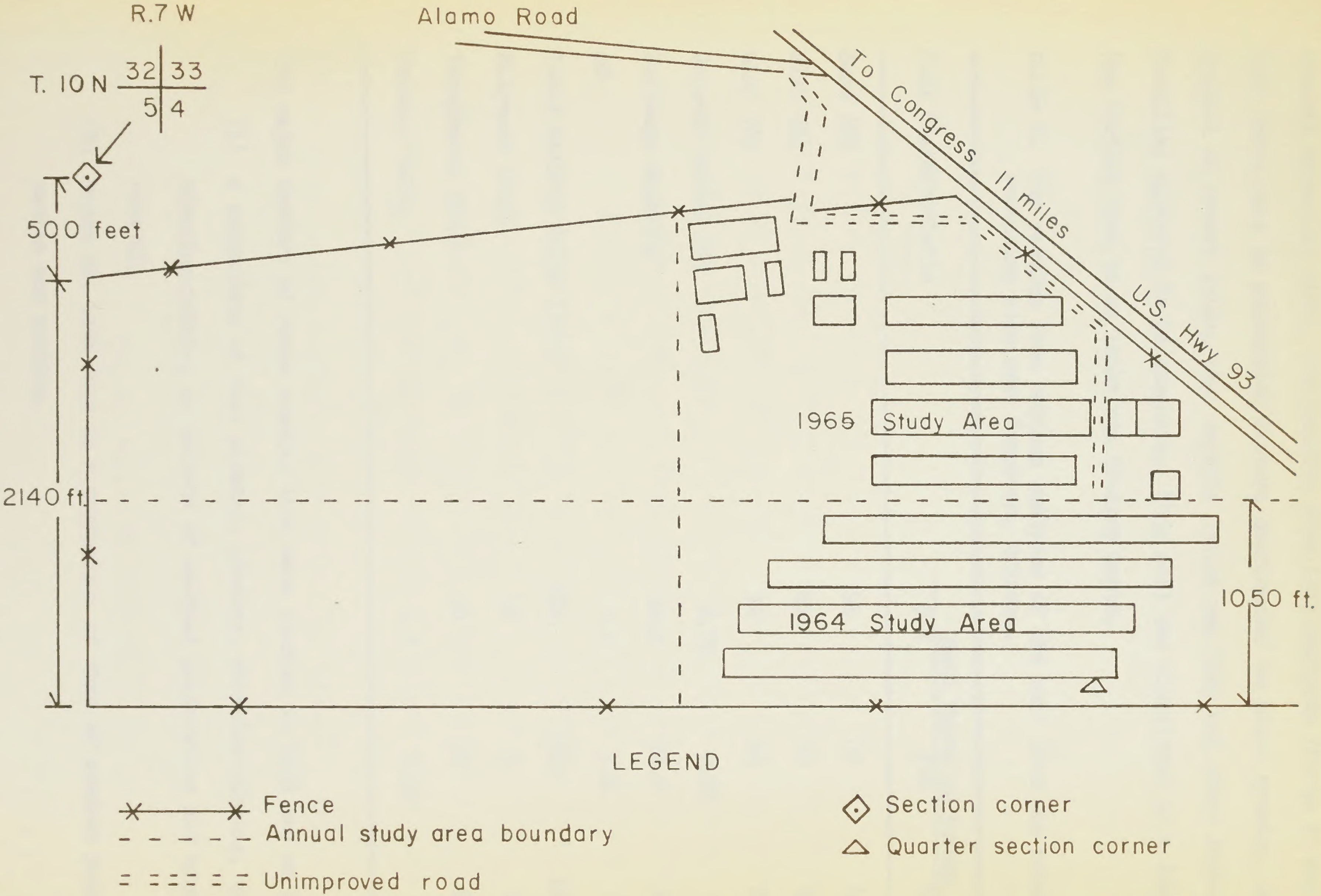

Figure 1. A diagram of the location of the range seeding studies near Congress, Arizona.

A soil analysis was made from composite soil samples taken from the general reseeding site. The results from this analysis (Table 2) indicated that there were no particular factors detrimental to plant growth. As is typical of desert soils, the organic matter was low; but other factors of fertility appeared to be adequate. This soil was classified as a loam from the surface down to at least the 10-inch depth.

Table 2. The results from various analyses of the soil from the range reseeding site near Congress, Arizona.

Soil Characteristic	Soil Depth in Inches		
	0-2	2-6	6-10
Sand (%)	41	40	43
Silt (%)	49	47	43
Clay (%)	10	13	14
Organic matter (%)	0.73	0.55	0.55
Exchange capacity	12.3	12.7	13.9
pH	7.3	7.4	7.5
Total Soluble Salts (PPM)	231.	315.	454.
Nitrogen (PPM)	18	7	17
Phosphorus (PPM)	28	16	20
Percent $CaCO_3$	1.0	0.42	0.82

The major factors of range seeding that were studied in 1965 are as follows:

(1) A comparison of root plowing, pitting, chaining-pitting, and clearing-pitting as methods of seedbed preparation and brush removal.

(2) March vs. late June as a comparison of time of seedbed preparation and seeding.

(3) Broadcasting vs. drilling as methods of seeding.

The experimental design was a complete-randomized block with four replications. The plot size was 100 by 200 feet. The combinations of the various factors of seeding are shown in the plot diagram in Figure 2.

The pitting was done with a cut-a-way pitting disk. The clearing operation consisted of clearing all vegetation from the plots with a bulldozer blade. The chaining was accomplished by dragging an anchor chain across the plots in first one direction and then in the opposite direction. The root plowing was done with conventional root plowing equipment. A Cyclone Seeder was used for broadcasting, and a Nisbet Drill was used for drilling.

At the time of the March seedbed preparation and seeding, there was a dense stand of annual forbs and grasses. This stand consisted mainly of filaree (Erodium cicutarium (L.) L'Her.). The soil condition was moist at this time. All seedings, both March and June, were made with Lehmann lovegrass at the rate of ½ pound per acre. Experience has indicated that this grass is the most responsive under the frequent droughts in these semi-arid rangelands in the Southern Deserts.

Plant counts were made in October, 1965 on both the 1964 and 1965 seedings. These counts consisted of the number of plants in 10 randomly-placed quadrats in each plot. The quadrat size was 1 by 5 feet.

It is appropriate at this time to review the results of the plant counts taken in 1964 on the seeding made during the same year. This review will serve for purposes of comparison with the plant counts made a year later on the same seeding. This comparison of the results from these two years can be seen in Table 3 for the 1964 count and in Table 4 for the 1965 count.

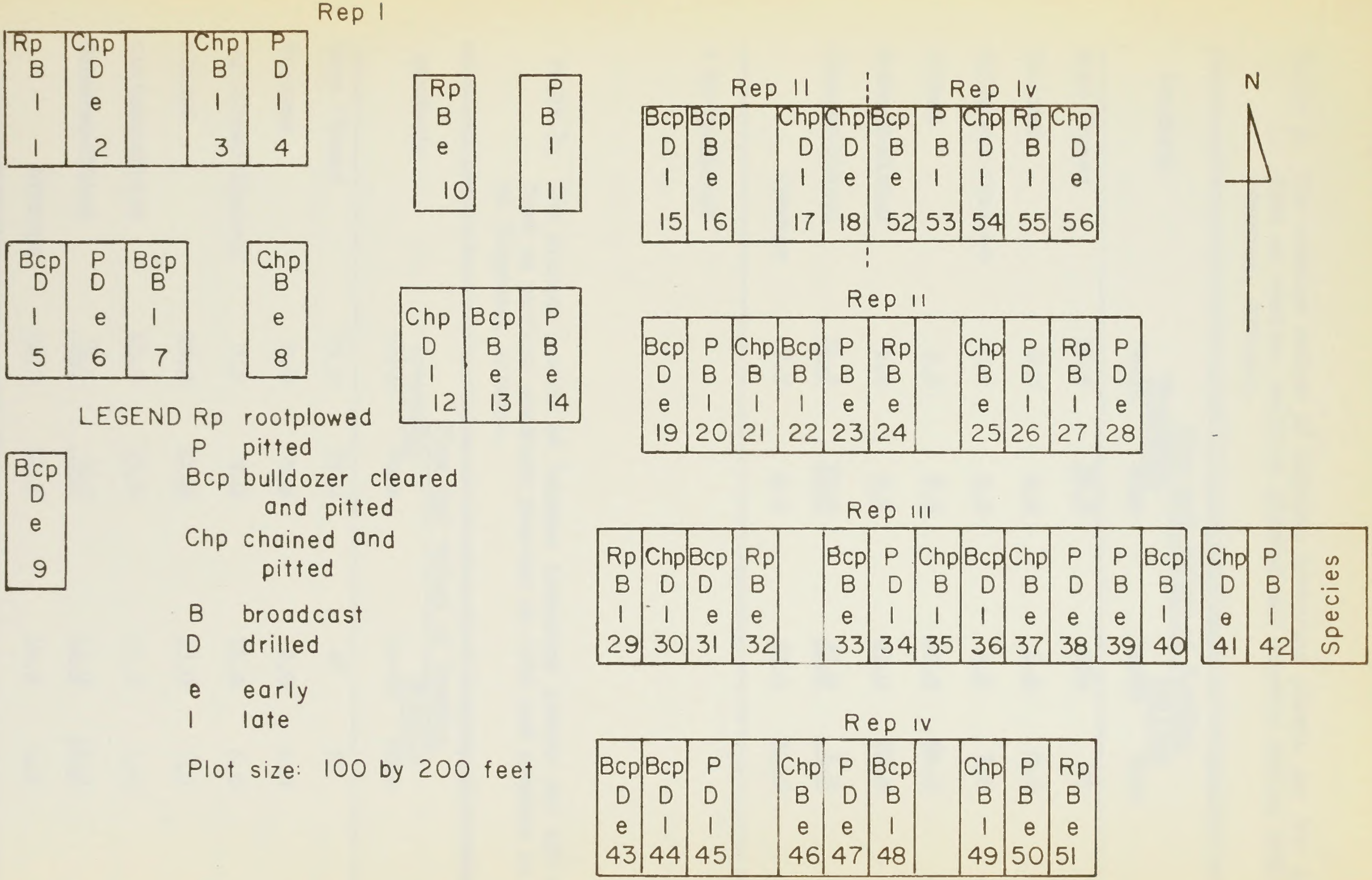

Figure 2. A plot diagram of the time and method of seeding on various seedbeds on rangelands near Congress, Arizona during 1965.

Table 3. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted and counted during 1964 at Congress, Arizona.

Seedbeds	Time and Method of Seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Root Plowed	18.5	22.0	NT*	NT	20.0
Chained	0.0	0.0	0.0	0.0	0.0
Bulldozer Cleared	0.0	0.0	4.5	1.0	1.3
Pitted	9.5	8.5	60.0	50.0	32.0
Chained-Pitted	1.0	5.5	29.0	18.0	13.3
Cleared-Pitted	14.0	13.0	22.0	1.0	12.5
Average	7.1	8.1	23.1	14.0	

* No Treatment

Table 4. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1964 and counted in 1965 at Congress, Arizona.

Seedbeds	Time and Method of Seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Root Plowed	23.0	59.0	NT	NT	41.0
Chained	0.0	0.0	8.0	0.0	2.0
Bulldozer Cleared	0.0	0.0	13.0	6.0	4.7
Pitted	28.0	12.0	23.0	7.0	17.5
Chained-Pitted	44.0	13.0	15.0	4.0	19.0
Cleared-Pitted	4.0	6.0	13.0	11.0	8.5
Average	16.5	11.5	14.5	4.6	

A comparison between these two tables reveals that there has been a general increase in the number of plants on all seedbeds. Because the plant counts presented in Table 4 represent mainly established plants, these data also indicate the relative effectiveness of various seedbeds. Root plowing was the most effective in terms of the best stand of grass. The other seedbed preparations in decreasing order of effectiveness were chaining-pitting, pitting, clearing-pitting, clearing, and chaining. Excepting for pitting, this was the same order of effectiveness assigned to these seedbeds in 1964. In general terms it has been observed that the order of relative effectiveness noted in the year of seeding is retained in subsequent years. The reasons for the marked decrease in the number of plants on the pitted seedbed are not known at this time. It should be noted that this decrease occurred on the drilled plots but not on the broadcast plots. In fact, most of the broadcast seedings increased in number of plants while the drilled seedings decreased in number of plants.

With respect to the effects of the time and method of seeding during 1964 (Table 3), drilling in March was more effective than drilling in June. There was no particular difference between boradcasting in March or June. From Table 4, it can be seen the effectiveness of drilling in March carried through the next growing season. Although the March broadcast seeding responded better from 1964 to 1965 than the June broadcast seeding, this difference may be due to experimental variation rather than representing a real difference. It is sufficient at this point to indicate that early seedings were equally or more effective than late seedings. Broadcasting was generally as effective as drilling except on seedbeds having comparatively little soil disturbance. For example, drilling was more effective only on the chained or bulldozer-cleared plots.

These two seedbed preparations were the least effective in over-all response. Their use in the Congress area is not recommended.

The seeding studies in 1965 were similar to those in 1964 excepting that the seedbed treatments consisting of chained only, or bulldozer-cleared only were omitted. As previously discussed, the seedbed preparations and the time and method of seeding in 1965 are shown in the plot diagram in Figure 2.

Plant counts were made in November on the 1965 seeding. Most of the plants at this time were small, ranging from one to six inches in height. The results from this count are shown on Table 5. It is surprising to note from this table the rather large number of plants on each of the seedbeds. It is expected that a large reduction in stand will occur by the end of the next growing season. That is, there is a greater plant population than can be supported by the general arid environment of this region. The major significance of the 1965 seeding will be to delineate the more effective seeding treatments which will be those having the least reduction in stand. As a liberal estimate, this range site could not support more than one perennial grass plant per square foot. Therefore, only a limited evaluation can be made on this seeding at this time.

Table 5. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1965 near Congress, Arizona. The counts were made in November, 1965.

Seedbeds	Time and Method of Seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Root Plowed	27	507	NT	NT	262
Pitted	31	441	238	223	233
Chained-Pitted	46	603	477	245	343
Cleared-Pitted	186	448	643	318	398
Average	72	449	344	196	

With respect to the time and method of seeding, again drilling in March was more effective than drilling in June. However, the March broadcast seedings were markedly inferior to the June broadcast seedings. This is in sharp contrast to the 1964 seedings in which the March broadcast seeding was as good or better than the equivalent June seeding. For future reference, it should be noted here that the weather conditions were unusual during the March seeding in 1965. Due to a late March rain, the soil was very moist during the seedbed preparation and seeding operations.

Whenever practical, the results from any particular experimental seeding are, in part, interpreted in terms of the weather during the growing season. Because moisture is the major limiting factor in rangeland seedlings, an analysis was made of the rate and amount of precipitation during the growing season. This analysis was based on daily absolute saturation deficits determined by the analytical procedures developed during 1964.1/ The validity of this analysis is discussed in detail under the Fredonia Area. From this analysis the amount of moisture effective for germination and seedling growth was determined. From July 1 through October 5, a total of 83 mm of rain fell (3.26 inches). Of this amount, only 19.3 mm was considered as effective moisture available for germination and seedling growth. A comparison between total precipitation and effective moisture is graphically presented in Figure 3. This comparison indicates that the only moisture effective for establishing the 1965 seeding occurred during the first week in September. Observations during the growing season support the above indication. On a percentage basis, this amounted to only 0.75 inch of effective moisture. The limited

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1/ Annual Progress Report for 1964. Brush Control and Revegetation on Southern Arizona Rangelands: Bowie and San Simon Areas.

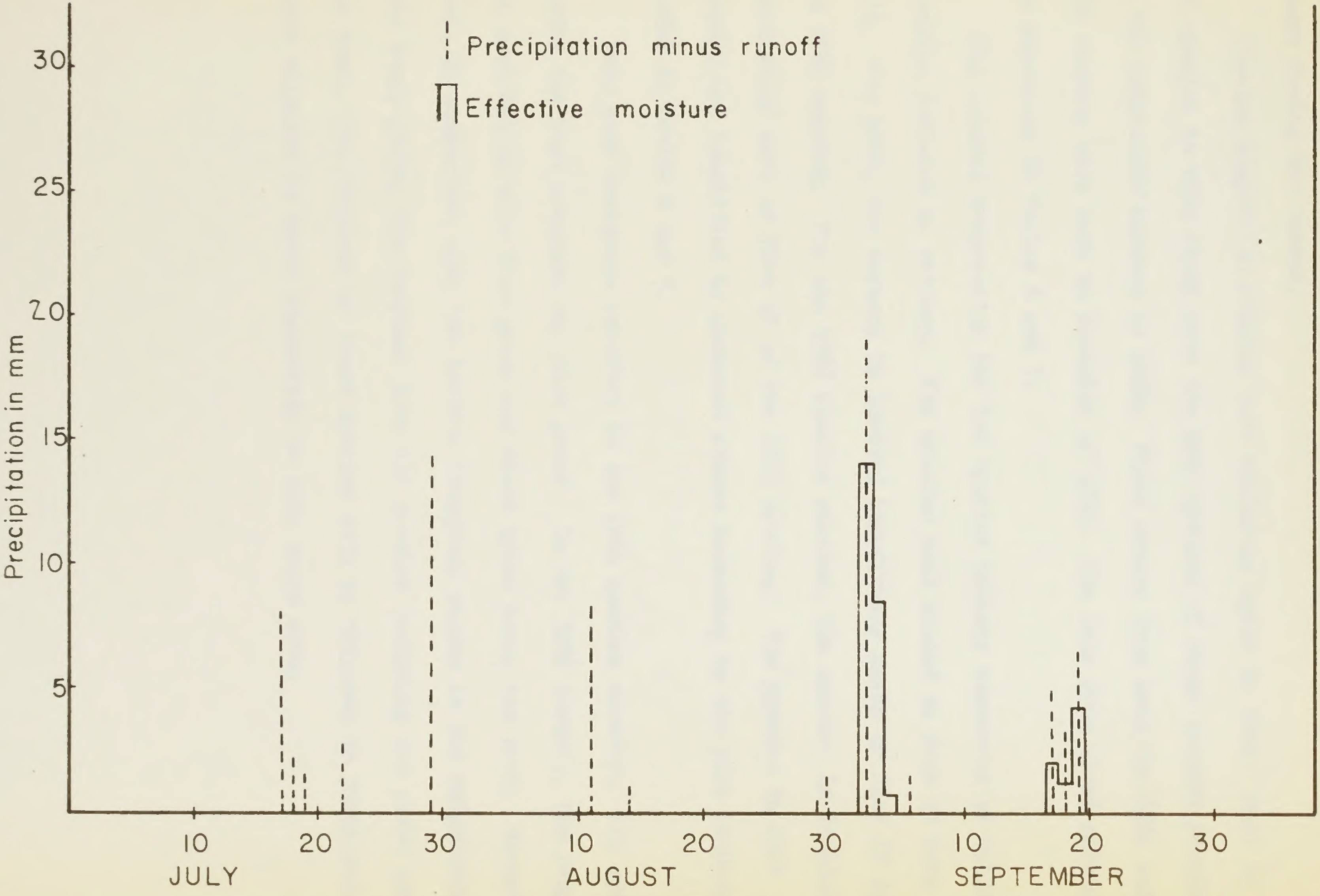


Figure 3. A comparison between the precipitation and the resultant effective moisture for plant growth during the summer of 1965 at Congress, Arizona.

effectiveness of the precipitation in the Congress area was due to the high rates of evaporation. Rates of over one inch of water per day were common during the summer.

Species adaptation studies were conducted again in 1965. Most of the species in this study were the same species of range grasses planted in the adaptation nursery in 1964. Plant counts from both the 1964 and 1965 nursery were made in November of 1965. The data from these counts are presented in Tables 6 and 7.

The seedbed preparation for the species nursery consisted of bulldozer clearing followed by pitting. The species were seeded on June 29 into dry soil. For 1964, the nursery is located immediately north of Plot 19 in the 1964 seeding. For the 1965 species studies, the nursery is located immediately east of Plot 42 in the 1965 seeding. The species in each nursery are identified by numbered stakes according to the plot numbers listed in Tables 6 and 7.

Very poor emergence resulted in the 1964 species nursery. The species giving the best response was blue grama. In the 1965 nursery, the response was much better with blue grama and black grama being the best. Nevertheless, in comparison with the Lehmann lovegrass seeded in the neighboring, main study plots, the response from all species including the grama grasses was poor. The response of these species will be followed in forthcoming years relative to their adaptation to this range area.

Table 6. The approximate number of plants per 50 square feet in the species adaptation nursery at Congress. Planted in 1964 and counted November, 1965.

Plot No.	Species	Common Name and Source	No. of Plants
1	Boer	Black grama	0
2	Bogr	Blue grama	24
3	Bohi	Hairy grama	0
4	Anis	Turkestan bluestem	0
5	Trca	Arizona Cottontop	9
6	Sema	Plains bristlegrass	3
7	Mupo	Bush muhly	0
8	Erch	Boer lovegrass	0
9	Ersu	Wilman lovegrass	0
10	Erin	Plains lovegrass	0
11	Bocu	Sideoats grama	0
12	Spcr	Sand dropseed	0
13	Spus	Creeping dropseed	3
14	Spco	Spike dropseed	6
15	Paco	Pretoria panicgrass	0
16	Paan	Blue panicgrass	6
17	Paob	Vine mesquite	0
18	Paha	Hall's panicgrass	0

Table 7. The number of plants per 50 square feet in the species adaptation nursery at Congress planted in 1965. Counted November, 1965.

Plot No.	Species	Common Name and Source	No. of Plants
1	Spcr	Sand dropseed A-16352	13
2	Spco	Spike dropseed A-14544	4
3	Spus	Creeping dropseed RM-NM-164	8
4	Erch	Boer lovegrass A-12752	1
5	Erin	Plains lovegrass A-14242	21
6	Ersu	Wilman lovegrass A-11965	23
7	Paha	Hall's panicgrass A-8002	9
8	Paan	Blue panicgrass A-130	2
9	Paco	Pretoria panicgrass A-12638	21
10	Anis	Turkestan bluestem A-14207-60	0
11	Paob	Vine mesquite A-11711-63	1
12	Sema	Plains bristlegrass A-14266	4
13	Trca	Arizona cottontop A-8084	3
14	Bogr	Blue grama A-12424	38
15	Boer	Black grama A-3730	38
16	Bohi	Hairy grama A-13274	26
17	Bocu	Sideoats grama A-3603	11
18	Mupo	Bush muhly A-13273	4
19	Anis	Turkestan bluestem A-14207	4

THE PIMA AREA

This area lies at an elevation of 3,100 feet northwest of Pima, Arizona and is known locally as the Mesquite Well area. The exact location of the range seeding studies in this area is depicted in Figure 4. It is believed that the Pima area is more favorable as a site for range seeding than the Congress area. The native vegetation is larger and more vigorous, and there is greater density of mesquite. It is also suspected that a more favorable distribution of summer precipitation occurs at the Pima area. A general description of the area was given in the 1964 Progress Report.

A survey was made of the native vegetation occurring on the 1965 study plots (Figure 7). The results of this survey are presented in Table 8. When compared with the survey made on the 1964 plots, it was noted that the shrub crown coverage was essentially the same for both sites. The main qualitative difference was in mesquite which increased in coverage while creosotebush decreased in coverage.

A soil analysis was made on the soils of the Pima area during 1965. The results of this analysis are in Table 9. The soil of the area classifies as a sandy loam. There were no factors present in the Pima soils which would be considered harmful or in excess. In comparison, the Congress soils appeared to be more fertile, having higher exchange capacities, and more nitrogen and phosphorus. In contrast to Congress, the coarser-textured soils of the Pima area had a higher population of weedy, summer annual grasses.

The following major factors of range seeding were studied during 1965 at the Pima area.

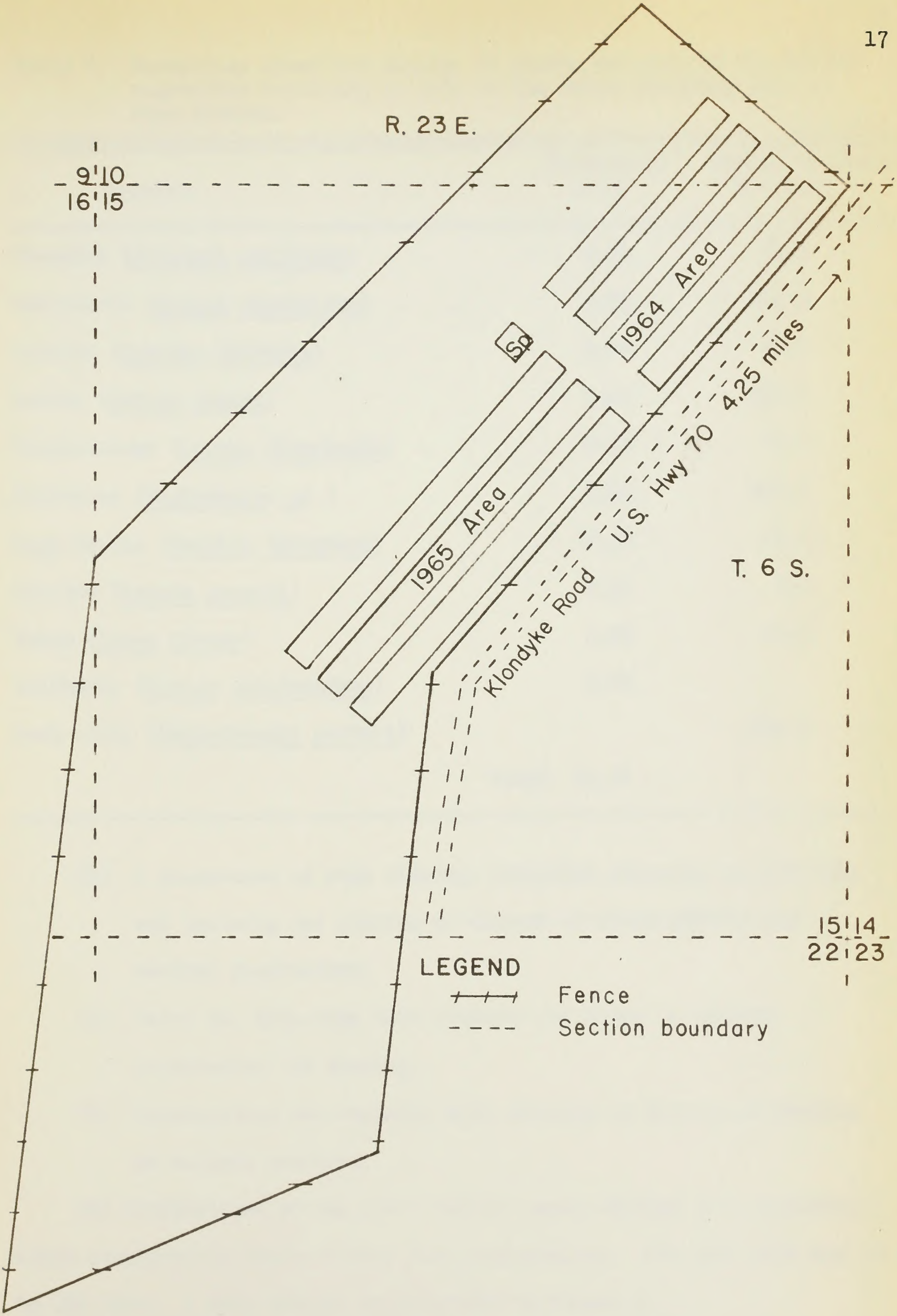


Figure 4. A diagram of the location of the range seeding studies near Pima, Arizona.

Table 8. Percentage cover and density of plants per acre of the native vegetation occurring in 1965 on the range reseeding site at Pima Arizona.

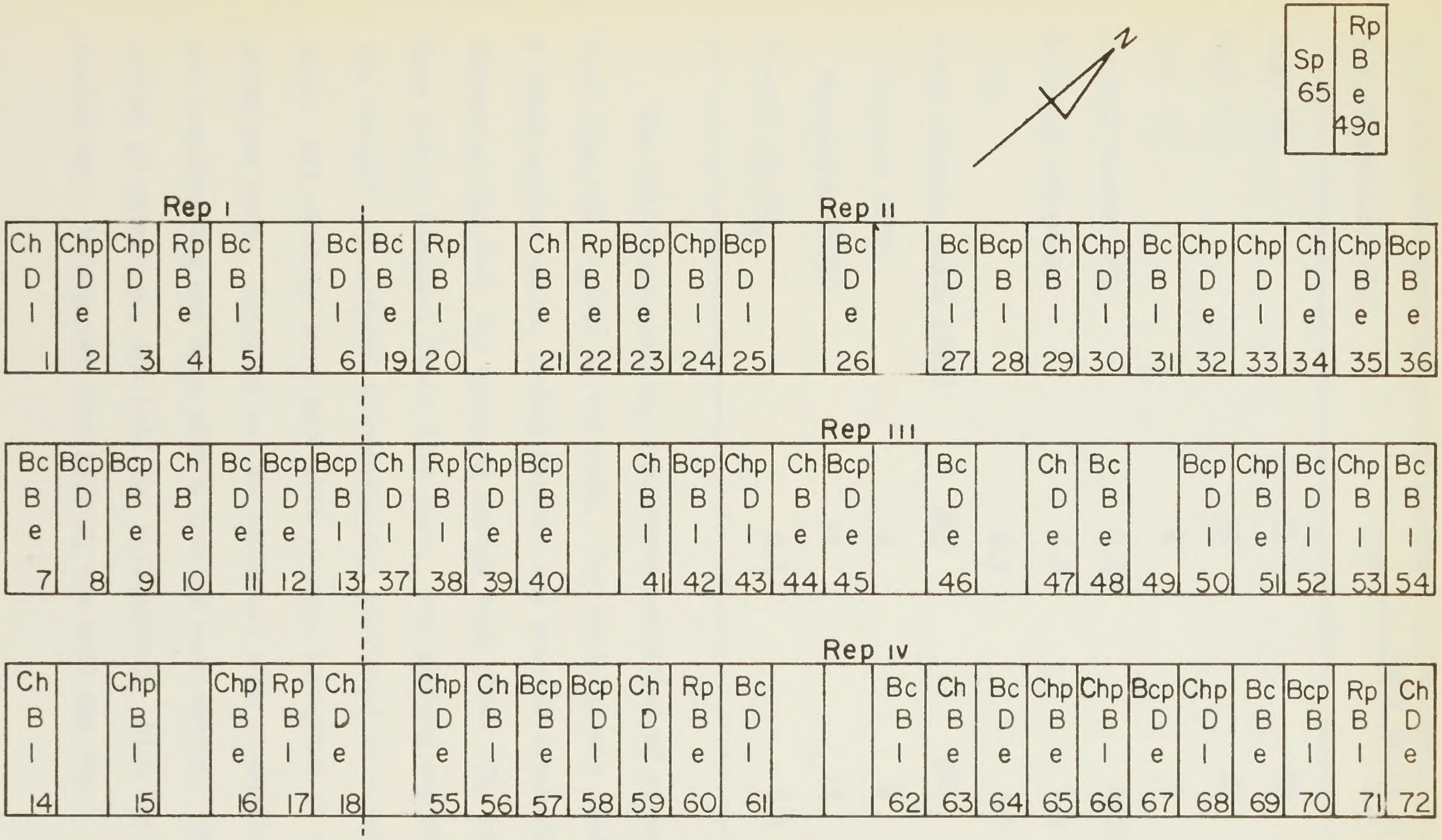
Species	Percentage Cover	Number of plants per acre
Mesquite (Prosopis juliflora)	4.10	54.3
Whitethorn (Acacia constricta)	3.24	111.8
Ephedra (Ephedra trifurca)	1.40	85.6
Bebbia (Bebbia juncea)	1.02	266.3
Creosotebush (Larrea divaricata)	0.90	22.9
Burroweed (Haplopappus sp.)	0.58	450.8
Cane cholla (Opuntia thornberi)	0.38	24.4
Catclaw (Acacia greggii)	0.32	8.0
Yucca (Yucca elator)	0.20	20.7
Wolfberry (Lycium californicum)	0.04	
Bush muhly (Muhlenbergia porteri)		106.6
Total	11.78	

(1) A comparison of root plowing, bulldozer clearing and pitting, and chaining and pitting as methods of brush removal and seedbed preparation.

(2) March vs. late June were compared for times of seedbed preparation and seeding.

(3) Broadcasting was compared with drilling as methods of seeding on various seedbeds.

All combinations of the above factors were combined in a randomized-block experimental design having four replications. The plot size was 100 by 200 feet. A plot diagram is presented in Figure 5.



LEGEND

Rp	rootplowed
Bc	bulldozer cleared
Bcp	bulldozer cleared and pitted
Ch	chained
Chp	chained and pitted

Seeding methods:	B	broadcast
	D	drilled
Time of seeding:	e	early (March)
	l	late (June)

Plot size: 100 by 200 feet

Figure 5. A plot diagram of the time and method of seeding on various seedbeds on rangelands near Pima, Arizona during 1965.

Table 9. The results from various analyses of the soil from the range reseeding site near Pima, Arizona.

Soil Characteristic	Soil Depth in Inches 0-2	2-6	6-10
Sand (%)	71	69	69
Silt (%)	25	27	25
Clay (%)	4	4	6
Organic matter (%)	0.29	0.22	0.18
Exchange capacity	5.5	7.3	8.4
pH	6.5	7.2	7.3
Total soluble salts (PPM)	223	261	207
Nitrogen (PPM)	4	4	2
Phosphorus (PPM)	22	12	6
Percent $CaCo_3$	0.7	0.6	0.6

The bulldozer-clearing treatments consisted of removing all vegetation from the surface of the soil. The chaining was conducted by dragging a heavy anchor chain, hooked between two crawler tractors, in first one direction and then the opposite across each plot. The root plowing was done with a standard Fleco Root Plow. The pitting superimposed on some of the chained and cleared treatments was performed by a cut-a-way pitting disk. All seedings were made with Lehmann lovegrass at the rate of ½ pound per acre. Drilling was accomplished with a modified Rangeland Drill, and broadcasting was done with a Cyclone hand seeder. During the March period of operation, the soil was sufficiently moist for optimum tillage conditions. During the June period, the soil was dry.

Both the 1964 and 1965 seedings were observed throughout the summer growing season. It is thought that the Pima area exemplified an important precipitation-plant growth relationship during 1965. That is, certain rain storms may provide sufficient moisture for the maintenance and growth of established grass, but which would not provide sufficient moisture for germination or seeding growth. Plant counts were made in November on both the 1964 and 1965 seedings. The data from these counts will be presented in the same fashion as was used for the Congress area to facilitate comparisons between these two range sites for both years.

In review, the results from the 1964 plant counts on the 1964 seeding are presented in Table 10. Table 11 presents the results from the 1965 counts on the same seeding. In comparison it is noted that, in general, the density of the stand about doubled during 1965. The relative differences between the various seedbeds in 1964 were retained through 1965. In order of decreasing effectiveness they are chained-pitted, cleared-pitted, rootplowed, bulldozer cleared, and chained. Except for rootplowing, this is the same order in the Congress studies. Likewise, the relative differences in time and method of seeding were retained. Drilling in March was more effective than drilling in June. The early broadcasting, however, was not as effective as the June broadcasting.

The same experimental variables were tested again in 1965 to determine the influence of other climatic variations. The results from the plant counts on the 1965 seeding are presented in Table 12.

Using the 1964 seeding as a basis of comparison, it can be seen that the relative effectiveness of the different seeding variables are evident again in the 1965 seeding. The major exception is the broadcast seeding

Table 10. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted and counted during 1964 at Pima, Arizona.

Seedbeds	Time and method of seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Chained-pitted	17	72	139	26	63
Cleared-pitted	16	67	68	46	49
Rootplowed	24	46	NT*	NT*	35
Bulldozer cleared	7	16	46	31	25
Chained	11	24	44	14	23
Average	15	45	74	29	

* No treatment.

Table 11. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1964 and counted in 1965 at Pima, Arizona.

Seedbeds	Time and method of seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Chained-pitted	59	123	230	97	127
Cleared-pitted	31	81	148	95	89
Rootplowed	67	129	NT	NT	98
Chained	23	66	116	44	62
Bulldozer cleared	22	34	105	75	59
Average	40	87	150	78	

in March which was particularly effective as compared with the June broadcast seeding. Again, the early drilled seeding was more effective than the June seeding. This appears to be a consistent factor in both years at Pima as well as at Congress. While the early broadcast seedings have not been consistantly more effective, these data indicate that these one or more factors are operating to bring about effectiveness. In other words, the direction of further research should be to isolate the factor(s) responsible and to control objectively the time of broadcast seeding to promote better stands. It is suspected the soil moisture level at the time of seeding may be a factor. One of the effects of drilling as contrasted with broadcasting is to place the seed in more intimate contact with soil moisture. Figure 8 illustrates the difference between seeding in March and June.

Table 12. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1965 and counted in November, 1965 near Pima, Arizona.

Seedbeds	Time and method of seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Rootplowed	276	79			178
Chained	71	2.5	34	11	29
Bulldozer cleared	259	5.0	73	18	88
Chained-pitted	44	4.0	81	52	45
Cleared-pitted	201	5.5	73	31	77
Average	170	19.3	65	28	

Certain other indications can be noted in comparison among the various seedbeds. Although not always the best, rootplowing has consistantly promoted the better stands of grass. The chained and cleared treatments

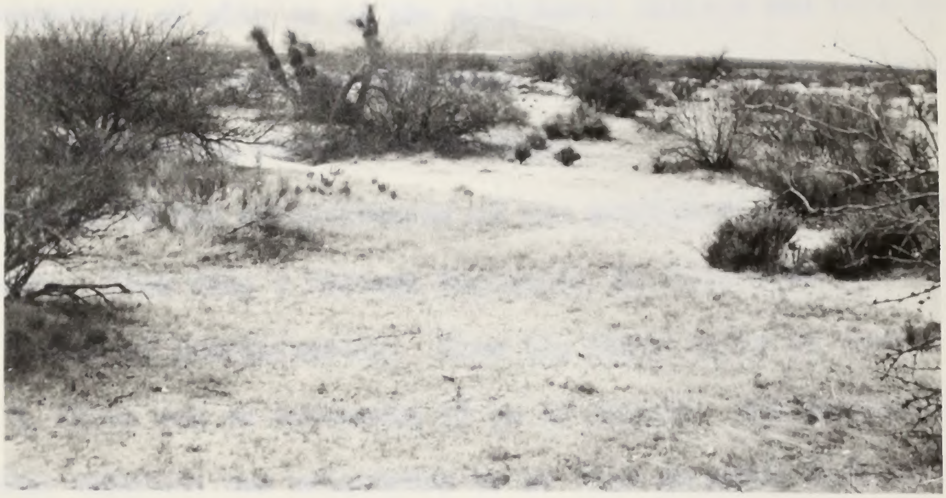


Figure 7. A representative view of the vegetation on the Pima Area before seedbed preparation in 1965.

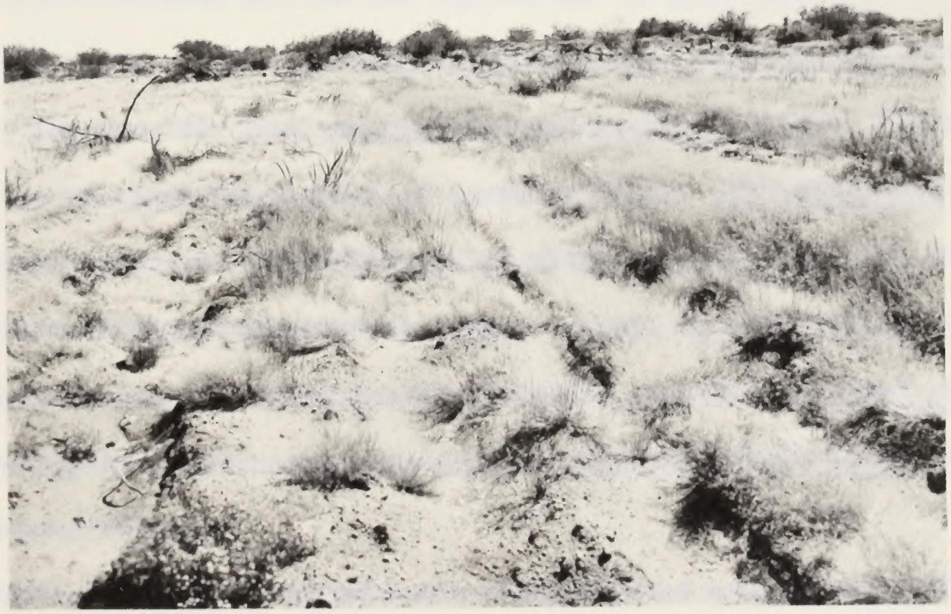


Figure 8. Lehmann lovegrass seeded in 1965 at Pima on pitted seedbeds. Right, seeded in March; Left, seeded in June.

are generally the poorest seedbeds at Pima. When pitting is superimposed on these treatments, the resulting stand is much better. It is not known at this time whether this improvement in stand is due to the water retaining properties of pits or to the additional tillage and soil disturbance caused by pitting. It would be desirable to compare pitting with disk harrowing in forthcoming studies on seedbeds.

An analysis of the effectiveness of the precipitation was made for the Pima area. From July 1 through September 30, this area received 158.5 mm (6.25) inches of precipitation. From the heavy rains on August 16 and September 3, there was an estimated 39 mm of runoff. The evaporation from the remaining moisture was calculated to be 77.6 mm which left 41.7 mm as effective moisture. On a percentage basis there was 24.7% runoff, 49.1% evaporation and 26.2 effective moisture. A comparison between the total and effective moisture is presented in Figure 9. The Congress Area had an effectiveness of 23.2% which was equivalent to 0.75 inches of moisture. The 26.2% effectiveness at Pima was equivalent to 1.64 inches of moisture.

In other words, there was about twice as much moisture available at Pima as at Congress for seed germination and seedling growth. This is reflected in the more dense stand of grass at Pima. The distribution of rain was also better at Pima although no critical evaluation can be made on the distribution patterns at this time. Until a proven relationship can be found between distribution of effective moisture and seed germination, an evaluation can be made only on an empirical basis after sufficient data have been obtained.

A species adaptation nursery was established at Pima during 1965. Most of the various species were drilled in late June on a seedbed that had been rootplowed in March. A few of the trashy-seeded species had to

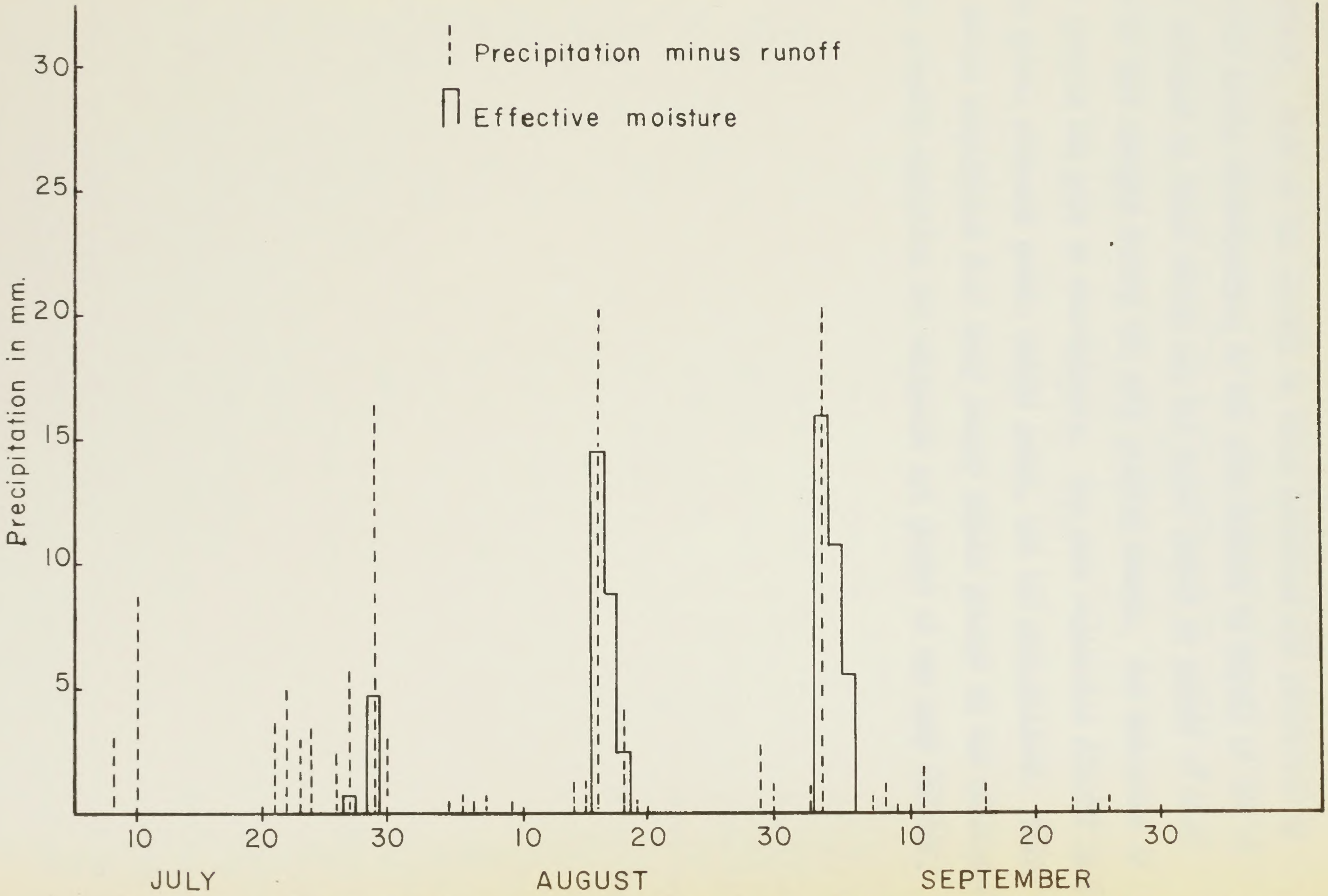


Figure 9. A comparison between the precipitation and the resultant effective moisture for plant growth during the summer of 1965 at Pima, Arizona.

be hand broadcasted. This nursery is located northwest of plot 41 of the main seeding study. Plant counts were made on both the 1964 and 1965 nurseries. Each of the species in these nurseries are identified by numbered stakes corresponding to the plot numbers in Tables 13 and 14. Also included in these tables are the total number of plants of each species that emerged during the 1965 growing season. The emergence of most species was poor or non-existant. The most responsive species were hairy grama, sideoats grama, buffel grass, and the panicgrasses. There was severe competition from weedy summer annual grasses in the nurseries which probably curtailed the emergence and growth of the many species.

Table 13. The total number of plants per 400 lineal feet in the species adaptation nursery at Pima, planted in 1964 and counted in 1965.

Plot No.	Species	Common Name and Source	No. of Plants
1	Bohi	Hairy grama	11
2	Boer	Black grama	0
3	Bocu	Sideoats grama	1
4	Bogr	Blue grama	0
5	Paob	Vine mesquite	0
6	Paha	Hall's panicgrass	2
7	Paco	Pretoria panicgrass	15
8	Paan	Blue panicgrass	11
9	Spus	Creeping dropseed	5
10	Spcr	Sand dropseed	0
11	Spfl	Mesa dropseed	4
12	Spco	Spike dropseed	2
13	Erch	Boer lovegrass	19
14	Ersu	Wilman lovegrass	20
15	Erin	Plains lovegrass	5
16	Trca	Arizona cottontop	0
17	Anis	Turkestan bluestem	32
18	Mupo	Bush muhly	0
19	Sema	Plains bristlegrass	0

Table 14. The equivalent number of plants per 500 square feet in the species adaptation nursery planted at Pima in 1965. Counted November, 1965.

Plot No.	Species	Common Name and Source		No. of Plants
1	Speo	Spike dropseed	A-14544	0
2	Sper	Sand dropseed	A-16352	0
3	Spai	Alkali sacaton	A-13156	0
4	Spus	Creeping dropseed		0
5	Erch	Boer lovegrass		0
6	Ersu	Wilman lovegrass	A-11965	2
7	Peci	Buffelgrass		10
8	Erin	Plains lovegrass	A-14242	0
9	Anis[1]	Turkestan bluestem	A-14207-60	3
10	Erbi	Bicolor lovegrass	A-14152	0
11	Paan	Blue panicgrass	A-130	30
12	Paha	Hall's panicgrass	A-800	117
13	Paco	Pretoria panicgrass	A-12638	47
14	Paob	Vine mesquite	A-11711	0
15	Sema	Plains bristlegrass	A-14266	23
16	Trca*	California cottontop	A-8084	10
17	Bohi*	Hairy grama		245
18	Bocu*	Sideoats grama		3390
19	Boer*	Black grama		0
20	Bogr*	Blue grama	A-12424	0
21	Mupo*	Bush muhly	A-13273	0
22	Peci*[2]	Buffelgrass		230
23	Anis*[2]	Turkestan bluestem		80

[1] Caryopses

[2] Trashy seed

* Broadcast seed

THE FREDONIA AREA

This phase of the project covers the progress of the range seeding studies near Fredonia, Arizona for the years 1964 and 1965. The initial report on the 1964 studies was made last year and only a brief summary concerning the progress for this year will be made. While the objectives of the project also encompass the Fredonia area, the methods of seedbed preparation and the species seeded differ considerably from those in the Southern Desert rangelands of Arizona. The Fredonia area is in the big sagebrush range type and the species concerned are mainly the cool season grasses. A detailed description of this area is included in previous progress reports. A diagram of the location of the various seeding studies in different years near Fredonia is presented in Figure 10.

The climatic factors during 1964 were disposed much more favorably toward the established seedings than for the establishment of new seedings. There was above average moisture during the spring which favored the growth of the cool season grasses, crested wheatgrass and Russian wildrye. The precipitation during the summer was low and, therefore, unfavorable for the growth of warm season grasses such as blue grama and for the germination of warm season grasses such as blue grama and for the germination of summer seeded species. This climatic pattern is reflected in the growth of plants from the 1964 seeding. The progress of this seeding is illustrated by the number of plants at different dates of plant counts. The data from these counts are given in Table 15.

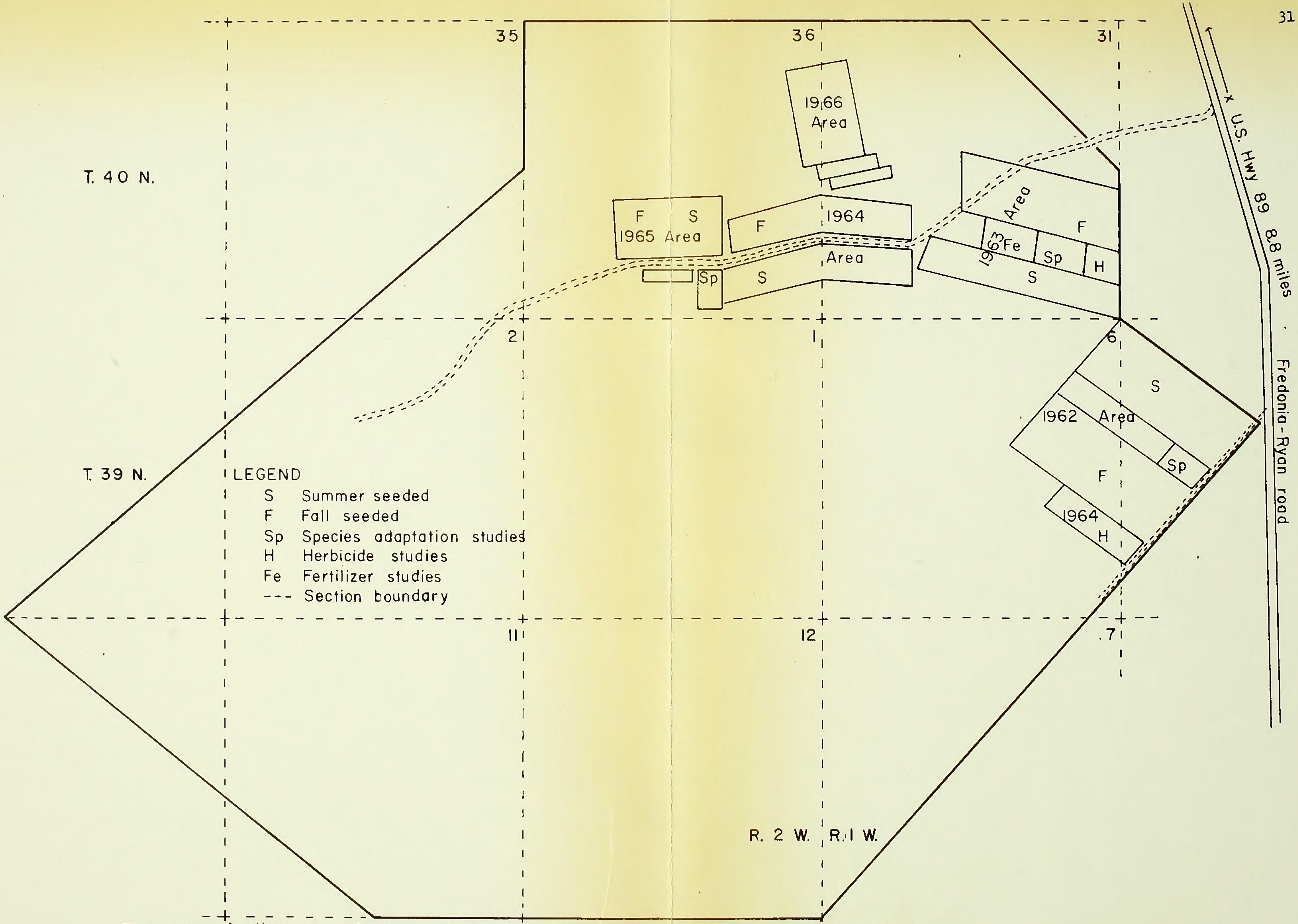


Figure 10. A diagram of the location of the range seeding studies near Fredonia, Arizona.

Table 15. The average number of plants per 100 square feet for various grasses planted on different seedbeds in 1964 near Fredonia.

Species and seedbed preparation	Method of seeding & date of count					
	Drilled			Broadcast		
	9-64	7-65	9-65	9-64	7-65	9-65
Crested wheatgrass (Summer seeded)						
Herbicide sprayed	722	390	280	11	8	4
Brush chopped	809	489	313	90	124	50
Chopped & pitted	631	352	301	101	117	76
Disk plowed	444	307	199	70	149	95
Burned	357	179	126	80	146	16
Blue grama (Summer seeded)						
Herbicide sprayed	307	28	20	232	16	4
Brush chopped	102	7	6	253	46	28
Chopped & pitted	79	7	5	198	55	53
Disk plowed	50	3	0	181	11	9
Burned	49	9	6	187	40	14
Crested wheatgrass (Fall seeded)						
Herbicide sprayed		216	148		0	0
Brush chopped		166	78		1	0
Chopped & pitted		274	187		46	22
Disk plowed		265	158		19	1
Burned		423	316		8	2
Russian wildrye (Fall seeded)						
Herbicide sprayed		203	164		2	0
Brush chopped		170	114		0	0
Chopped & pitted		254	202		21	9
Disk plowed		117	63		3	1
Burned		348	202		22	12

Certain pertinent points are evident from the number of plants present on these dates. From the emergence of the summer seeded species in August, 1964 up to September, 1965 there has been a considerable reduction in stand. However, there was less reduction in the stand of crested wheatgrass than there was in the stand of blue grama. The spring moisture apparently favored the growth of the wheatgrass more than the grama grass. Possibly blue grama takes longer to become established than crested wheatgrass.

Both crested wheatgrass and Russian wildrye produced a better stand from drilling than from broadcasting. Blue grama however produced as well from broadcasting as from drilling. It is suspected that the poorer stand of blue grama from drilling might have been due to the difficulty of drilling bulky, blue grama seed and not to the superiority of the broadcast seedings. There was a tendency for the broadcast seedings to perform best on the pitted seedbeds. With the drilled seedings there does not appear to be any consistant trend for one seedbed to be more productive than the others. In fact, it was expected that the plowed seedbeds would have produced a better stand than was indicated by the data. On the other hand, the response from the fall seeding on the burned seedbed was better than expected (Figure 11). The final analysis of the data from the 1964 seeding should not be made until it is fully established. It is still subject to climatic variations and competition from weedy plants.

In addition to the plant counts on the species seeded in 1964, counts were also made on the number of sagebrush and globe mallow plants in the various seeding treatments. These data, presented in Table 16, support visual observations that the more the soil is disturbed the more densely infested are the seedbeds with globe mallow (Figure 12). That is, the

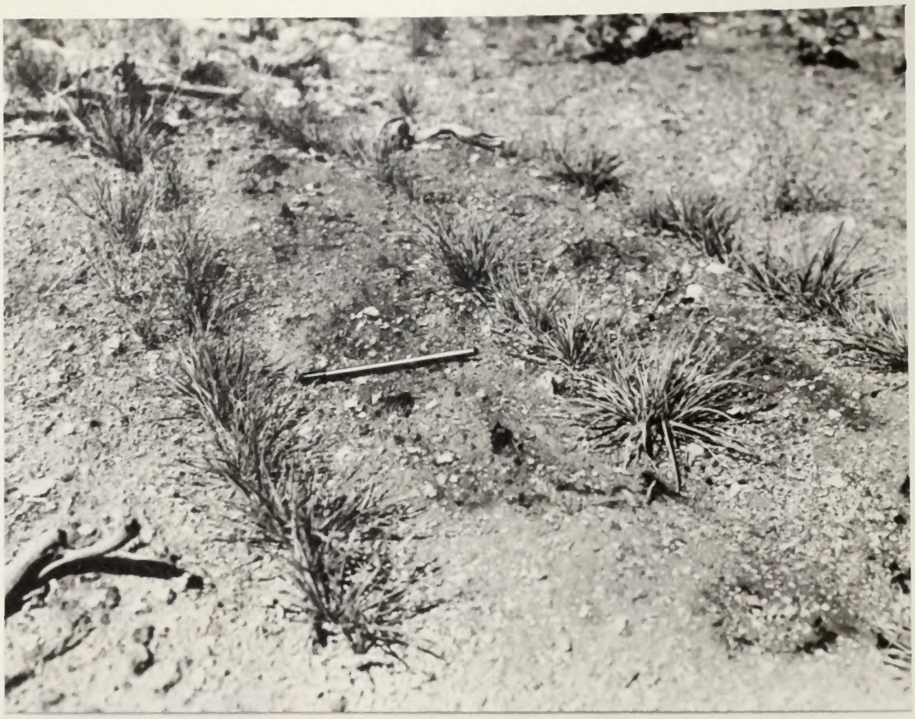


Figure 11. Russian wildrye drilled into a seedbed prepared only by burning away the sagebrush. Planted September 1964 and photographed September 1965.

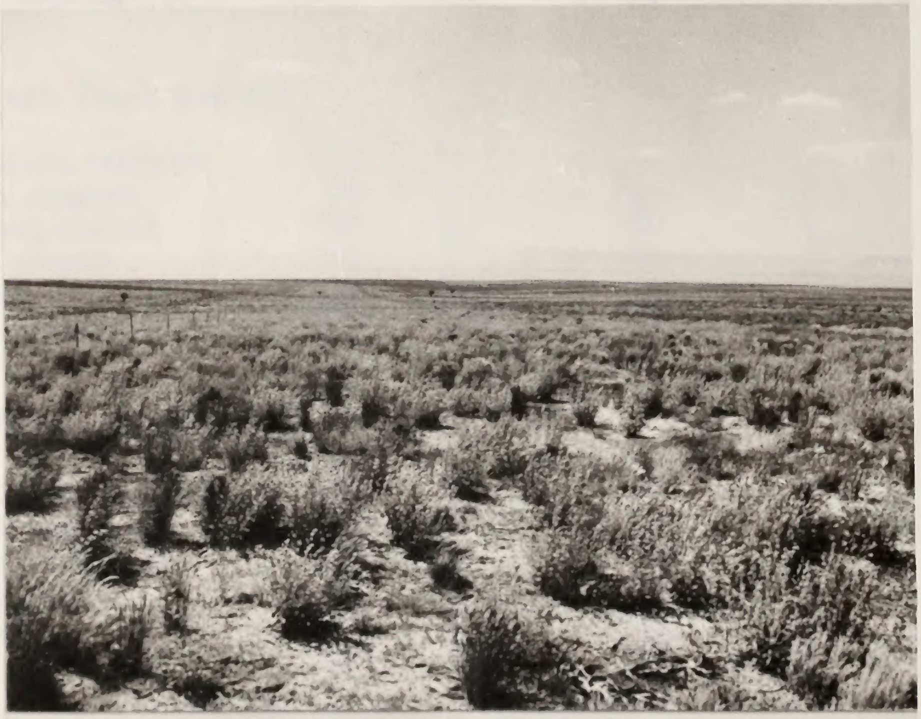


Figure 12. A typical aspect of globe mallow, light-colored plants, in a stand of crested wheatgrass near Fredonia. Photographed June 1965.

Table 16. The number of plants of grass, sagebrush, and globe mallow per 100 square feet on different seedbeds seeded in 1964. Counts were made September, 1965 near Fredonia, Arizona.

Species seeded and seedbed preparation	Method of seeding grass					
	Drilled			Broadcast		
	Grass	Sage	G. Mallow	Grass	Sage	G. Mallow
Crested wheat (Summer seeded)						
Herbicide sprayed	280	2	10	4	14	2
Brush chopped	313	8	36	50	6	21
Chopped-pitted	301	2	87	76	7	44
Disk plowed	199	9	73	95	1	50
Burned	126	0	41	16	0	44
Average	243	4.2	49	48	5.6	32
Blue grama (Summer seeded)						
Herbicide sprayed	20	16	18	4	8	6
Brush chopped	6	7	21	28	13	19
Chopped-pitted	5	3	53	53	3	45
Disk plowed	0	2	41	9	1	34
Burned	6	0	41	14	1	12
Average	7	5.6	35	21	5.2	23
Crested wheat (Fall seeded)						
Herbicide sprayed	148	6	10	0	6	10
Brush chopped	78	3	16	0	7	17
Chopped-pitted	187	4	10	22	7	6
Disk plowed	153	3	37	1	2	44
Burned	316	1	9	2	0	12
Average	176	3.4	16	5	4.4	18
Russian wildrye (Fall seeded)						
Herbicide sprayed	164	8	2	0	10	0
Brush chopped	114	5	12	0	8	12
Chopped-pitted	202	2	3	9	3	1
Disk plowed	63	3	72	1	3	123
Burned	202	0	13	12	3	9
Average	149	3.6	20	4	5.4	29

chopped and undisturbed seedbeds have a much lighter stand of globe mallow than do the pitted and/or plowed seedbeds. Furthermore, there is a tendency for the summer prepared seedbeds to have a heavier stand of glob mallow than those prepared in early fall. Because drilling creates additional soil disturbance, there is more globe mallow in the drilled seedbeds than on the broadcasted ones for the summer seeding. The greater density of globe mallow on the plowed seedbeds might be one of the factors which has curtailed their expected production.

The 1965 seeding studies were concerned with the following major factors:

1. A comparison of different seedbeds prepared by brush chopping and brushland plowing.
2. A comparison of six species of grass on all seedbeds with all methods of seeding. These species were created wheatgrass (Agropyron desertorum), siberian wheatgrass (A. sibericum) blue grama (Bouteloua gracillis), Russian wildrye (Elymus junceus), spike dropseed (Sporobolus contractus), and sand dropseed (S. crytandrus). Blue grama was summer seeded only; pubescent wheatgrass (A. tricophorum) was seeded in its place in the fall seeding.
3. A comparison of seeding methods consisting of broadcasting and drilling before and after the seedbeds were prepared.
4. A comparison of the time of seeding on July 7, with October 15.
5. All factors were fully randomized in a block and the blocks were replicated four times.

The combination of the various factors can be more readily visualized by referring to the plot diagram in Figure 13 for the summer seeding and to Figure 14 for the fall seeding.

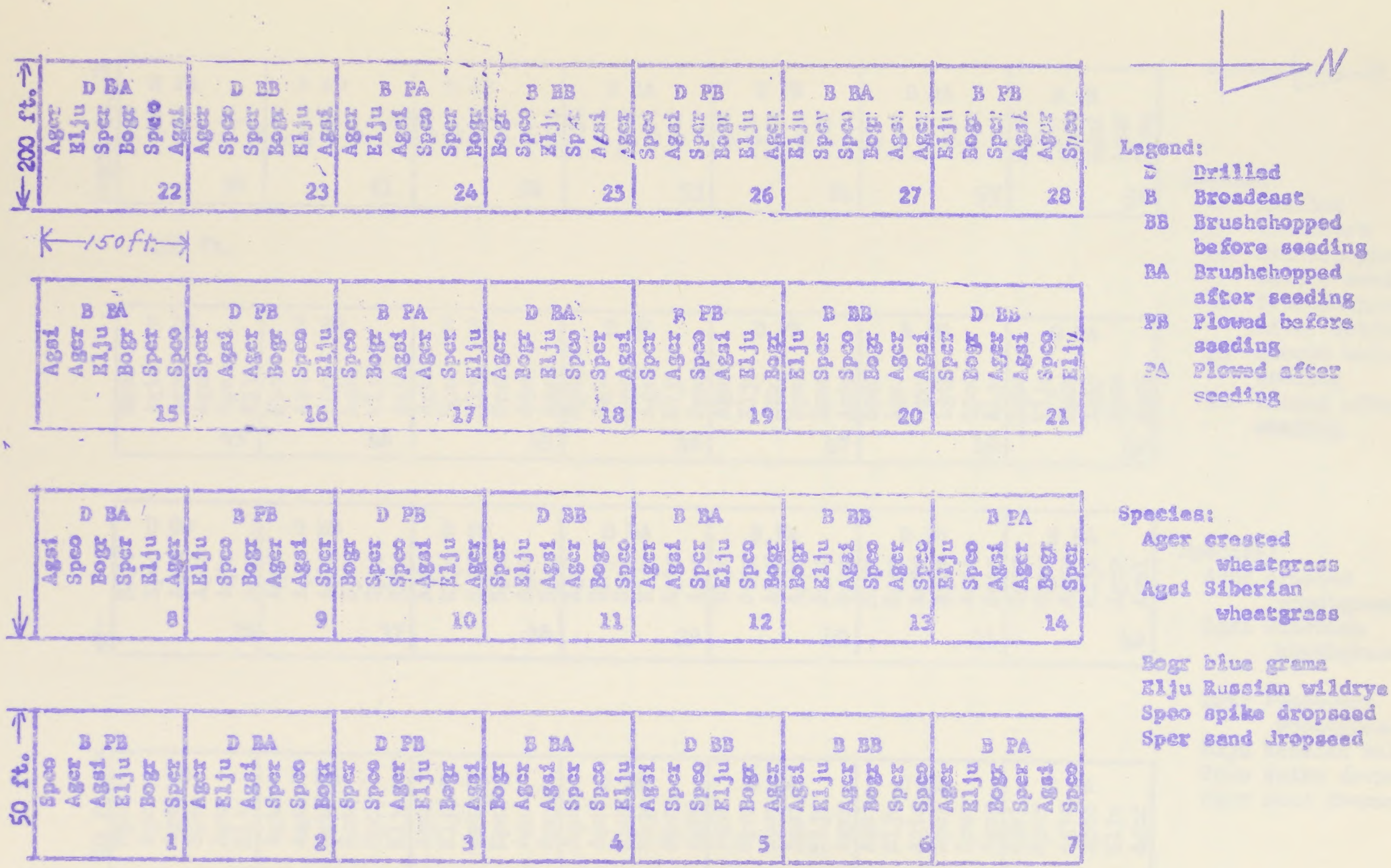
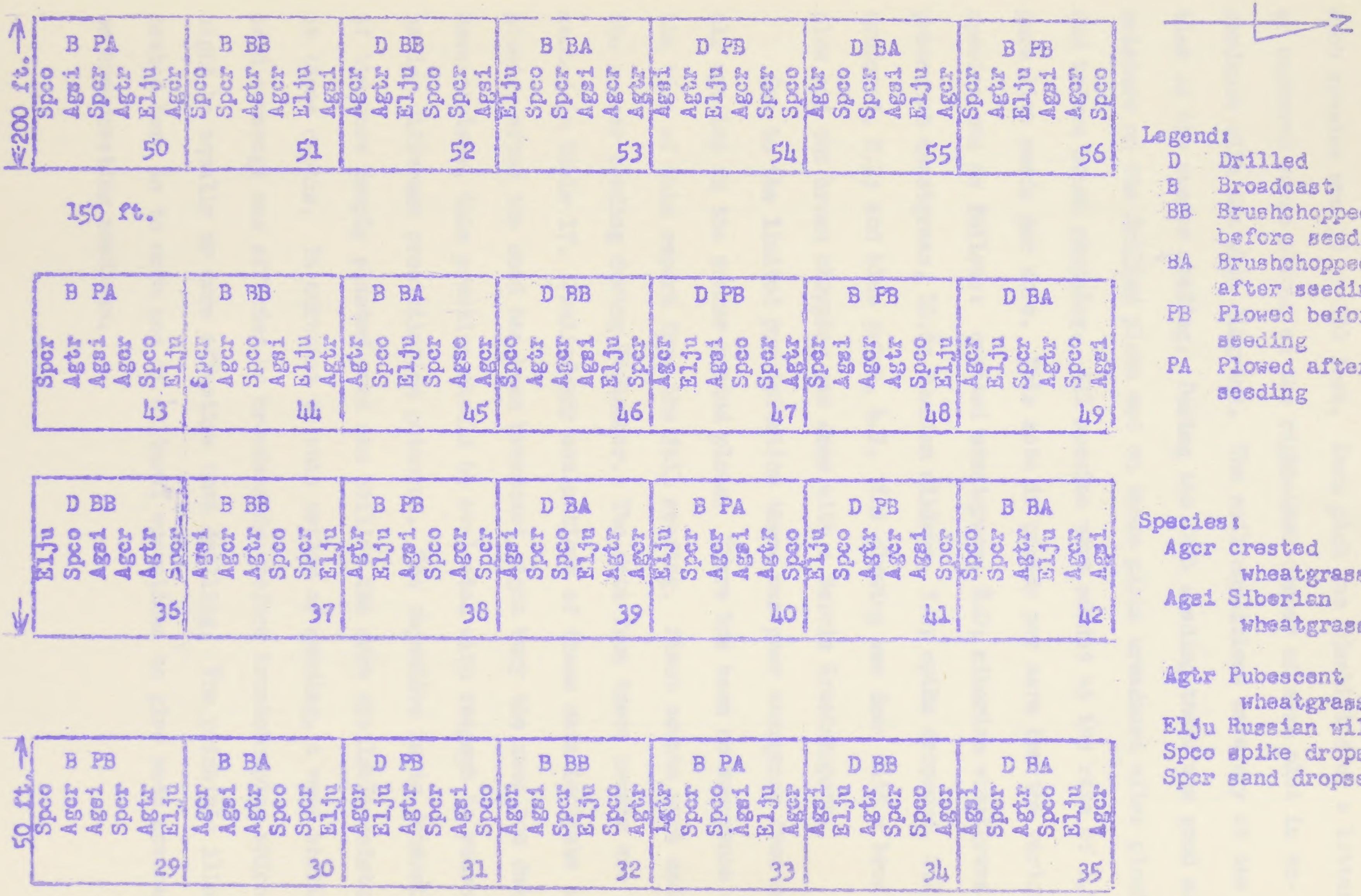

N
200 ft.
150 ft.
50 ft.
22 D BA Ager Elju Sper Bogr Speo Agsi
23 D BB Ager Speo Sper Bogr Elju Agsi
24 B PA Ager Elju Agsi Speo Sper Bogr
25 B BB Bogr Speo Elju Sper Agsi Ager
26 D PB Speo Agsi Sper Bogr Elju Ager
27 B BA Elju Sper Speo Bogr Agsi Ager
28 B PB Elju Bogr Sper Agsi Ager Speo
15 B BA Agsi Ager Elju Bogr Sper Speo
16 D PB Sper Agsi Ager Bogr Speo Elju
17 B PA Speo Bogr Agsi Ager Sper Elju
18 D BA Ager Bogr Elju Speo Sper Agsi
19 B PB Sper Ager Speo Agsi Elju Bogr
20 B BB Elju Sper Speo Bogr Ager Agsi
21 D BB Sper Bogr Ager Agsi Speo Elju
8 D BA Agsi Speo Bogr Sper Elju Ager
9 B PB Elju Speo Bogr Ager Agsi Sper
10 D PB Bogr Sper Speo Agsi Elju Ager
11 D BB Sper Elju Agsi Ager Bogr Speo
12 B BA Ager Agsi Sper Elju Speo Bogr
13 B BB Bogr Elju Agsi Speo Ager Speo
14 B PA Elju Speo Agsi Ager Bogr Sper
1 B PB Speo Ager Agsi Elju Bogr Sper
2 D BA Ager Elju Agsi Sper Speo Bogr
3 D PB Sper Speo Ager Elju Bogr Agsi
4 B BA Bogr Ager Agsi Sper Speo Elju
5 D BB Agsi Sper Speo Elju Bogr Ager
6 B BB Agsi Elju Ager Bogr Sper Speo
7 B PA Ager Elju Bogr Sper Agsi Speo
Legend:
D Drilled
B Broadcast
BB Brushchopped before seeding
BA Brushchopped after seeding
PB Plowed before seeding
PA Plowed after seeding
Species:
Ager crested wheatgrass
Agsi Siberian wheatgrass
Bogr blue grama
Elju Russian wildrye
Speo spike dropseed
Sper sand dropseed

Figure 13. The plot diagram showing the seedbeds, methods of seeding, and the species seeded on July 7, 1965 near Fredonia, Arizona.


200 ft.
B PA Spco Agsi Spcr Agtr Elju Agcr 50
B BB Spco Spcr Agtr Agcr Elju Agsi 51
D BB Agcr Agtr Elju Spco Spcr Agsi 52
B BA Elju Spco Spcr Agsi Agcr Agtr 53
D PB Agsi Agtr Elju Agcr Spcr Spco 54
D BA Agtr Spco Spcr Agsi Elju Agcr 55
B PB Spcr Agtr Elju Agsi Agcr Spco 56
150 ft.
B PA Spcr Agtr Agsi Agcr Spco Elju 43
B BB Spcr Agcr Spco Agsi Elju Agtr 44
B BA Agtr Spco Elju Spcr Agse Agcr 45
D BB Spco Agtr Agcr Agsi Elju Spcr 46
D PB Agcr Elju Agsi Spco Spcr Agtr 47
B PB Spcr Agsi Agcr Agtr Spco Elju 48
D BA Agcr Elju Spcr Agtr Spco Agsi 49
D BB Elju Spco Agsi Agcr Agtr Spcr 36
B BB Agsi Agcr Agtr Spco Spcr Elju 37
B PB Agtr Elju Agsi Spco Agcr Spcr 38
D BA Agsi Spcr Spco Elju Agtr Agcr 39
B PA Elju Spcr Agcr Agsi Agtr Spco 40
D PB Elju Spco Agtr Agcr Agsi Spcr 41
B BA Spco Spcr Agtr Elju Agcr Agsi 42
50 ft.
B PB Spco Agcr Agsi Spcr Agtr Elju 29
B BA Agcr Agsi Agtr Spco Spcr Elju 30
D PB Agcr Elju Agtr Spcr Agsi Spco 31
B BB Agcr Agsi Spcr Elju Spco Agtr 32
B PA Agtr Spcr Spco Agsi Elju Agcr 33
D BB Agsi Elju Agtr Spcr Spco Agcr 34
D BA Agsi Spcr Agtr Spco Elju Agcr 35
N

Legend:

D	Drilled
B	Broadcast
BB	Brushchopped before seeding
BA	Brushchopped after seeding
PB	Plowed before seeding
PA	Plowed after seeding

Species:

Agcr	crested wheatgrass
Agsi	Siberian wheatgrass
Agtr	Pubescent wheatgrass
Elju	Russian wildrye
Spco	spike dropseed
Spcr	sand dropseed

Figure 14. The plot diagram showing the seedbeds, methods of seeding, and the species seeded in October, 1965 near Fredonia, Arizona.

Each seedbed plot was 150 by 200 feet in size. The plot size for each species was 30 by 200 feet. Each plot was identified by a lettered or numbered stake placed at the right-hand corner of each plot in accordance with the plot diagrams. The soil conditions were dry at the time of the summer seeding. During the fall seeding there was good soil moisture on the drilled plots and on those plots broadcast after plowing and before brush chopping. All species were seeded at the rate of 1,000,000 pure live seeds per acre. This rate in pounds per acre for the various species was as follows: crested wheatgrass, 8.0; siberian wheatgrass, 7.5; pubescent wheatgrass, 10.8; Russian wildrye, 7.0; spike dropseed, 2.2; sand dropseed, 2.2; and blue grama, 4.1. The plowing was done with a brushland plow and the brush chopping was done with a Servis Brushchopper.

Due to the limited precipitation there was poor emergence from most all species in the summer seeded plots. There has been no emergence at the time of this report from the fall seeding. Plant counts were made on the summer seeding during September. The data from these counts are presented in Table 17. Preliminary evaluations of these data indicate that plowing after the seed has been broadcast might bury the seed too deeply. Nevertheless, this practice should be evaluated with respect to years having different precipitation patterns. The objective is to determine if the more deeply planted seed can utilize the more available moisture at these depths. In contrast to this method of seeding, a very shallow seed coverage was afforded by broadcasting before brushchopping which might be equally or more effective than drilling. The principle illustrated here is to make use of cultural operations to give seed coverage on broadcasting seedings.

Table 17. The average number of plants of various species per 100 square feet on different seedbeds planted by various seeding methods near fredonia in the summer of 1965.

Method of seeding and seedbed preparation	Species seeded						Average
	Agcr	Agsi	Bogr	Elju	Spco	Spcr	
Drilled:							
Plowed before seeding	17	24	4	15	4	1	11
Chopped before seeding	14	16	3	23	2	3	10
Chopped after seeding	15	24	7	11	1	5	10
Broadcast:							
Plowed before seeding	10	18	6	24	3	2	10
Plowed after seeding	3	1	0	3	0	1	1.3
Chopped before seeding	14	26	3	9	1	1	9
Chopped after seeding	25	42	2	28	3	7	18
Average	14	21	3.5	16	2	2.8	

These data support the results from previous years indicating that crested wheatgrass, siberian wheatgrass, and Russian wildrye are responsive species even in years of poor rainfall. As can be noted from Table 17, these species were the most responsive during the summer of 1965. Similarly, blue grama was not sufficiently dependable to produce a satisfactory stand.

A species adaptation nursery was established in both July and October. Two seedbeds traversed the length of the nursery; each were 100 feet in width. Each species was seeded across each seedbed; one seedbed was disk plowed and the other was brush chopped. Each species plot measured about 10 by 200 feet. Thirty-one different species or accessions were seeded at each seeding date.

The evaluation of various species for seeding on the sagebrush rangelands of Arizona has been in progress since 1962. This amounts to four nurseries including the one planted in 1965. All of these nurseries were counted during September of 1965. The stands of each species in these nurseries are now indicative of certain pertinent points:

(1) They indicate those species which, although may be easily established during favorable years, are not drought or cold hardy. This is illustrated by the large decrease in numbers from year to year of plants such as the lovegrasses.

(2) They indicate a few species which have become established in each nursery and have persisted from year to year. These same species are usually the only ones to respond when planted during years of limited rainfall. As a tentative rating of better adapted range grasses of this area, one could list the

following: crested wheatgrass, siberian wheatgrass, pubescent wheatgrass, Russian wildrye, and Indian ricegrass from certain selections.

Future species studies are intended to be restricted to testing a wider range of accessions of the more adapted species. The current status in terms of number of plants per 100 square feet is shown for all species in all nurseries in the following Tables 18, 19, 20, and 21.

As previously indicated, the precipitation during the growing season at Fredonia was too light for good plant growth. Detailed weather records covering temperature, relative humidity, precipitation, wind speed, and evaporation from an evaporation pan were maintained throughout the summer growing season. This permitted the same type of comparison as was made at Congress and Pima on the effectiveness of the precipitation. From each daily rain the absolute saturation deficit was subtracted. This deficit was assumed to be proportional to the actual water evaporated from a free water surface. It was calculated from the daily records obtained from hygrothermograph charts. It was not know, however, how closely the calculated values agreed with the actual evaporation. To evaluate the agreement, if any, an evaporation pan and an anemometer were put into operation. The evaporation pan wasthe same as a U.S. Weather Bureau Class A land pan. The daily readings from these insturments for the month of September were then plotted parallel with the calculated water loss as shown in Figure 15.

It was found that the average hourly absolute saturation deficit closely approximated the amount of evaporation from the evaporation pan during a 24-hour period. It was then noted that the closest agreement

Table 18. The number of plants per 100 square feet in a species adaptation nursery planted in July and October, 1962 near Fredonia, Arizona.

Plot No.	Species	Common Name	Date Counted 8/27/63	 8/21/64	 9/21/65
		Summer Seeded			
1	Bocu	Sideoats grama	8	9	2
2	Boer	Black grama	10	8	1
3	Bogr	Blue grama	9	4	3.5
4	Atca	Four-wind saltbush	2	5	3.0
5	Orhy	Indian ricegrass	11	6	5.5
6	Sema	Plains bristlegrass	4	9	4.0
7	Muwr	Spike muhly	97	12	49.0
8	Anis	Tuckestan bluestem	0	0	1.0
9	Erbi	Bicolor lovegrass	18	1	1.5
10	Erle	Lehmann lovegrass (3506)	2	1	0
11	Erle	Lehmann lovegrass (A-68)	327	1	0
12	Ercu	Weeping lovegrass	24	0	0.5
13	Erch	Boer lovegrass	156	0	0
14	Spai	Alkali sacaton	25	29	12.0
15	Spus	Creeping dropseed	51	8	6.5
16	Spcr	Sand dropseed	98	44	20.0
17	Spco	Spike dropseed	617	136	89.0
18	Agcr	Crested wheatgrass	34	25	27.0
		Fall Seeded			
1	Agcr	Crested wheatgrass	17	43	19.5
2	Elju	Russian wildrye (Colo.)	30	44	32.5
3	Elju	Russian wildrye (Utah)	7	22	12.0
4	Agcr	Crested wheatgrass (N. Dak.)	13	28	15.5
5	Agin	Intermediate wheatgrass	37	49	26.5
6	Agsm	Western wheatgrass (Utah)	5	23	12.5
7	Agin	Intermediate wheatgrass (Amur)	15	18	10.0
8	Agtr	Pubescent wheatgrass	35	48	21.0
9	Elci	Giant wildrye	2	2	3.5
10	Agsi	Siberian wheatgrass	33	96	47.5
11	Elsa	Salina wildrye	6	6	3.5
12	Sami	Burnet	5	0	0.0
13	Atca	Four-wind saltbush	0	2	0.5
14	Orhy	Indian ricegrass	10	12	6.5
15	Eula	Winterfat	0	0	0.0
16	Orhy	Indian ricegrass (Wyo.)	0	0	0.5
17	Orhy	Indian ricegrass(Wyo.-Tucson)	1	0	0.0
18	Orhy	Indian ricegrass (Red-desert)	2	1	0.5
19	Sihy	Squirreltail (Springerville)	11	11	12.0

Table 19. The number of plants per 100 square feet in a species adaptation nursery planted in July and September, 1963 near Fredonia, Arizona.

Plot No.	Summer Seeded		Date Counted		
	Species	Common name and source	8/22/63	8/20/64	6/8/65
1	Bogr	Blue grama (Comm'l)	972	273	140
2	Bocu	Sideoats grama A-3603	446	253	110.5
3	Boer	Black grama A-3730	392	184	96.5
4	Sami	Burnet A-14173	14	1	2.0
5	Atca	Four-wing saltbush A-16652	11	18	9.0
6	Sema	Plains bristlegrass A-9971	14	17	6.5
7	Orhy	Indian ricegrass 3763	6	33	11.5
8	Orhy	Indian ricegrass 4406	16	118	36.5
9	Orco	Blue ricegrass A-10696	43	27	8.0
10	Ster	Mandan ricegrass A-15538	1	11	5.5
11	Ledy	Green sprangletop A-14254	641	1	0.5
12	Muwr	Spike muhly A-8604	456	160	160.5
13	Tedr	Karoo grass A-14408	299	62	29.0
14	Dier	Fingergrass A-12616	141	0	0.0
15	Spcr	Sand dropseed A-16352	823	462	218.0
16	Spco	Spike dropseed A-14544	202	57	49.0
17	Spus	Creeping dropseed A-14399	438	115	46.5
18	Spai	Alkali sacaton A-13156	238	111	69.0
19	Erle	Lehmann lovegrass A-68	1102	0	0.0
20	Erle	Lehmann lovegrass A-14107-08	1806	29	1.0
21	Erle	Lehmann lovegrass A-14328	957	1	0
22	Erbi	Bicolor lovegrass A-14152	328	4	0
23	Erch	Boer lovegrass A-67	192	1	0
24	Agcr	Crested wheatgrass (Comm'l)	36	85	61.5

Table 19. (Cont'd)

	Fall Seeded		Date counted	
Plot No.	Species	Common name and source	8/20/64	8/8/65
1	Agcr	Crested wheatgrass (Comm'l)	46	25
2	Elju	Russian wildrye (Comm'l)	167	71.5
3	Agin	Intermediate wheatgrass A-12496	190	63.5
4	Agsi	Siberian wheatgrass (Comm'l)	283	41.5
5	Agcr	Pubescent wheatgrass (Luna)	263	94.5
6	Elci	Giant wildrye A-13036	5	9.5
7	Eula	Winterfat SS1-62	0	0
8	Eula	Winterfat A-16161	0	0
9	Orco	Blue ricegrass A-10696	40	1.5
10	Orhy	Indian ricegrass 4406	82	32.0
11	Orhy	Indian ricegrass 3763	17	11.5
12	Orhy	Indian ricegrass (Red desert)	13	4.0
13	Stor	Mandan ricegrass A-15538	1	2.0
14	Sihy	Squirrel-tail (Springerville)	27	11.0
15	Agin	Intermediate wheatgrass (Amur)	109	32.5
16	Agtr	Pubescent wheatgrass 4302	121	54.0
17	Agam	Western wheatgrass	56	31.5
18	Agin	Intermediate wheatgrass 2788-25	221	66.0
19	Sami	Burnet 2741	1	0
20	Atca	Four-wing saltbush 4348	8	2.5

Table 20. The number of plants per 100 square feet in a species adaptation nursery planted in July and September, 1964 near Fredonia, Arizona.

Plot No.	Species (seeded early July)	Source	Date counted 7/8/65	 9/3/65
1	*Agropyron tricophorum*	(Luna)	38.5	48.5
2	*Bouteloua gracilis*	(Stock)	26	33.0
3	*B. gracilis*	A-12424	23	7.0
4	*B. curtipendula*	A-3603	20.5	42.5
5	*B. eriopoda*	A-3730	9.5	8.0
6	*Eragrostis lehmanniana*	A-14107	0	0.5
7	*E. bicolor*	A-1415	0	0.5
8	*E. curvula*	(Comm'l)	0	1.5
9	*Muhlenbergia porteri*	A-13273	0	1.0
10	*M. wrightii*	A-8604	0	0.5
11	*Sanquisorba major*	A-14173	3.5	3.5
12	*Tetrachne dregei*	A-14408	0	0
13	*Digitaria eriantha*	A-12616	0	0
14	*Leptochloua dubia*	A-12254	0	0
15	*Oryzopsis hymenoides*	A-12242	5.0	5.5
16	" "	A-14719	7.0	1.5
17	" "	A-16503	9.0	2.5
18	*Sporobolus airoides*	A-13156	3.5	3.5
19	*S. contractus*	A-14544	13.5	7.5
20	*S. cryptandrus*	A-16352	63.0	70.0
21	*S. usitatus*	A-14399	2	2.5
22	*S. flexuosus*	A-10117	2	1.0
23	*Andropogon ischaemum*	A-14207	30	36.5
24	*Atriplex canescens*	A-16652	10	7.5
25	*Sanquisorba minor*	A-14173	1.5	0.5
26	*Agropyron crestatum*	(Comm'l)	146	87.5

Table 20. (Cont'd.)

Plot No.	Species (seeded early September)	Source	Date counted 7/8/65	 9/3/65
1	*Agropyron tricophorum*	(Luna)	15	15.5
2	*A. crestatum*	(Comm'l)	62.5	35.5
3	*Kangaroo Valley rye*		14	1.
4	*A. intermedium*	A-12496	41.5	37
5	*A. intermedium*	(Amur) 6	36	31
6	" "	(Greenar)	54.5	31
7	*Eragrostis lehmanniana*	A-14107	0	0
8	*Agropyron tricophorm*	(Topar)	115.5	65
9.	*A. sibericum*	P-27	26	42
10	*A. interms*	(Whitmar)	58	40.5
11	*A. smithii*	(Comm'l)	7	4
12	*Stiporyzopsis*	A-15539	0.5	1
13	*Festuca ovina durinscula*	(USFS)	15	0.5
14	*Elymus juncus*	(Comm'l)	66	50.5
15	*Elymus triticoides*	(Local)	39	41.5
16	*Oryzopsis hymenoides*	A-12242	17	4
17	" "	A-14719	30	8.5
18	" "	A-16503	28	16
19	*Bouteloua gracilis*	A-12424	0.5	0.5
20	*Sporobolus contractus*	A-14544	2	0.5
21	*S. cryptandrus*	A-16352	0	1
22	*Mendora scabra*	A-16807	0	0.5
23	Purshia glabrata	(USFS)	0	0
24	*Atriplex canescens*	A-16652	0	0.5
25	*Sanquisorba minor*	A-14173	10	1.5

Table 21. The species planted in the species observation plots at Fredonia, Arizona on July 9 and October 18, 1965. Values are plants per 100 square feet for the summer seeding.

Plot No.	Species	Source	Date counted 9/16/65
1	*Agropyron crestatum*	(Comm'l. Neb. & Montana)	1.5
2	*A. desertorum*	(Nordan)	8
3	*A. trichophorum*	(Topar)	1
4	*A. trichophorum*	(Luna)	4.5
5	*A. intermedium*	A-12496	3
6	*A. intermedium*	(Greenar)	2.5
7	*A. smithii*	(Comm'l.)	0.5
8	*A. sibericum*	A-10675	2.0
9	*A. sibericum*	(Comm'l. Idaho)	5.0
10	*Elymus juncus*	(Comm'l. Montana)	2.5
11	*Atriplex canescens*	A-16831	0
12	*Muhlenbergia porteri*	A-13273	0
13	*Sanquisorba minor*	A-14173	0
14	*Sporobolus contractus*	A-14544	0
15	*S. cryptandrus*	(Comm'l. Yuma)	0
16	*S. airoides*	(Wilcox)	0
17	*Andropogon ischaemum*	A-14207	3.0
18	*Leptochloa dubia*	A-14254	0
19	*Oryzopsis hymenoides*	(Mohave)	1.5
20	" "	(Holbrook)	0
21	" "	P-2575	1.0
22	" "	(Albuquerque)	0
23	" "	(Shiprock)	0
24	*Muhlenbergia wrightii*	(Cimarron)	0
25	*Tetrachne dregei*	A-14408	0
26	*Bouteloua curtipendula*	A-3603	4.5
27	*Eragrostis lehmanniana*	A-14107-108	0
28	*Bouteloua eriopoda*	A-3730	0
29	" "	(Naipai)	0.5
30	*B. gracilis*	(Captan)	0.5
31	" "	(Comm'l. Colorado)	0

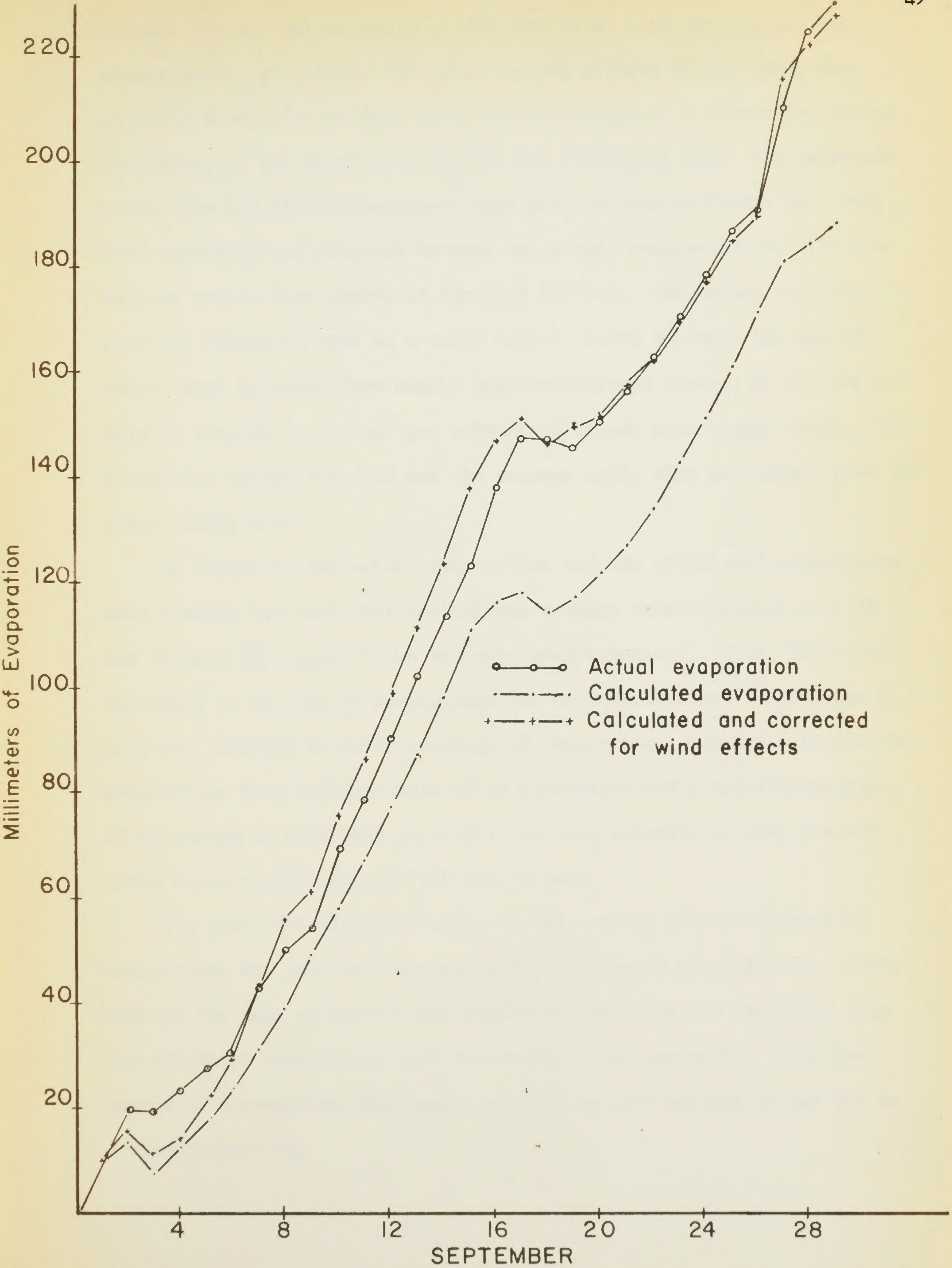


Figure 15. A comparison of actual and calculated evaporation at Fredonia, 1965.

between the two values occurred when the total wind for the day was approximately 100 miles. To allow for the effects of the wind, the absolute saturation deficit (ASD) was multiplied by a correction factor consisting of the total wind for the day divided by 100. The corrected values for the ASD for September were also plotted in Figure 15. Very good agreement was obtained between the actual evaporation and the calculated evaporation corrected for wind effects. The values used for plotting Figure 15 were on a daily basis. Since the data for the ASD values were obtained from weekly hygrothermograph charts, it was desireable to compare the actual and calculated values on a weekly basis. The correction factor for wind was the average daily wind determined from the total weekly wind.

In Figure 16 the actual evaporation and the calculated evaporation were plotted for each week through the growing season between July 28 and October 18. Again there was very good agreement. Thus, it is not necessary to utilize an evaporation pan to determine the evaporation in an area. Instead of daily readings of evaporation, one can estimate the evaporation from weekly totals of an anemometer and a hygrothermograph. If it should be desirable to convert such an estimate to lake evaporation, a pan coefficient of 0.70 can be used.

The above correlations assign to the various effective rainfall comparisons for each of the areas a high degree of significance. There remains the task of correlating available soil moisture resulting from the effective moisture of each rainstorm. More correctly, it is the degree of correlation that needs to be determined because it may not be a linear function.

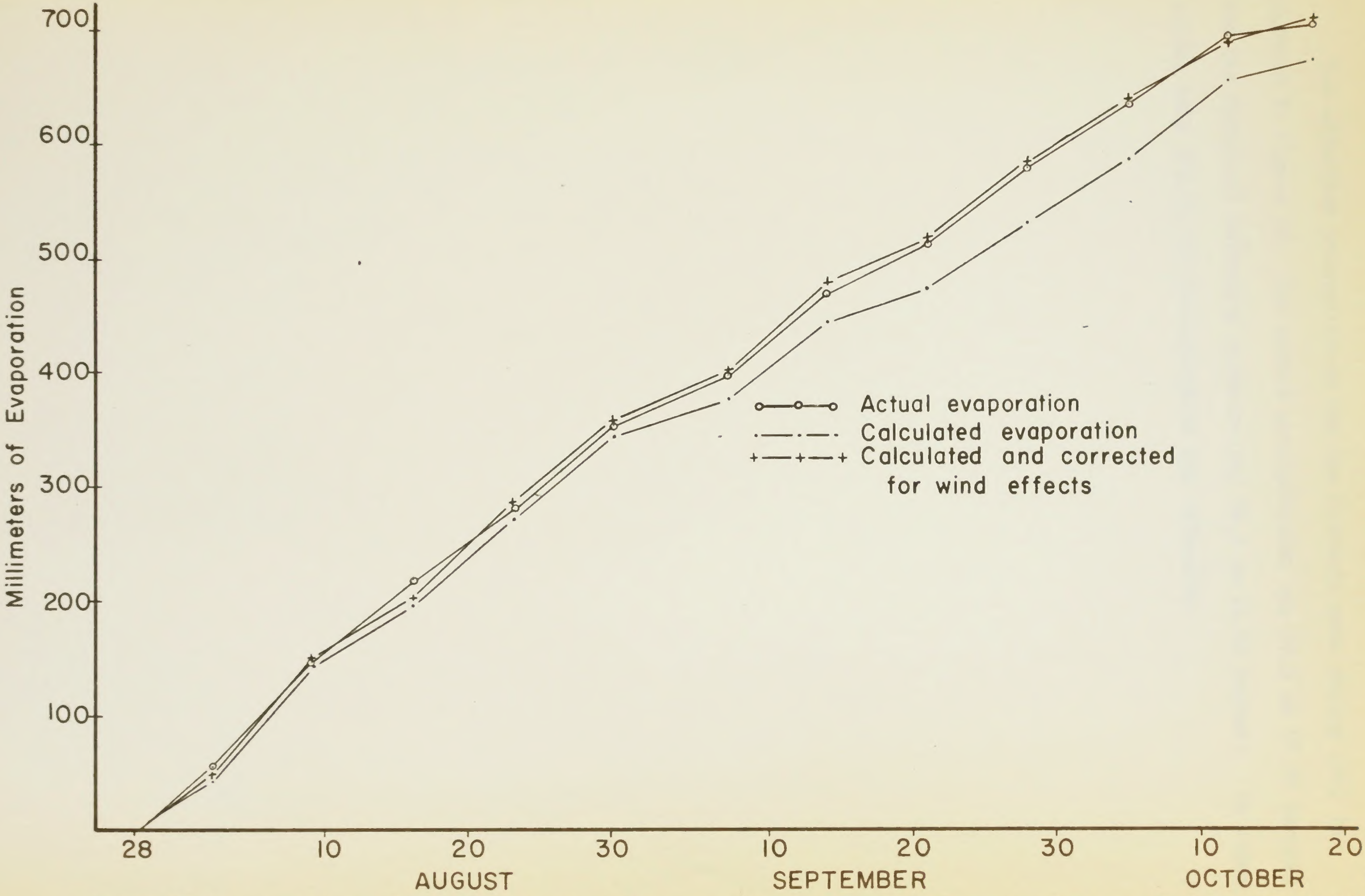


Figure 16. A comparison of actual and calculated evaporation through the growing season at Fredonia, 1965.

The effective precipitation for the Fredonia area during 1965 is plotted in Figure 17. The actual precipitation was 69.3 mm (2.72 inches) and the resultant effective moisture was 26.3 mm (1.08 inches). In other words, only 38% of the precipitation was effective.

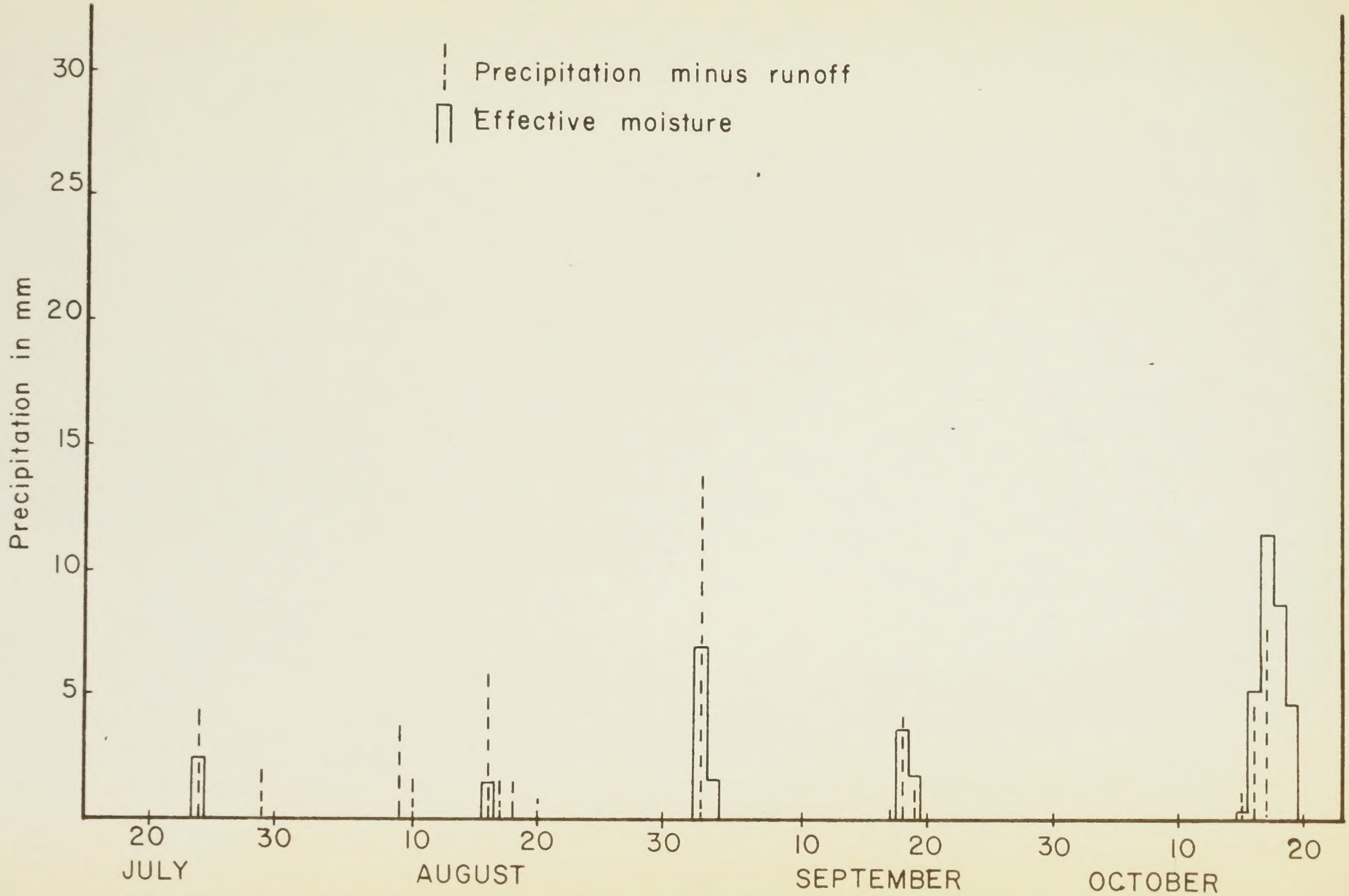


Figure 17. A comparison between the precipitation and the resultant effective moisture for plant growth during the summer of 1965 at Fredonia, Arizona.

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